

A. Sherriff Scott R.C.A.

AN ATLAS OF MUSCULOSKELETAL EXPOSURES

H. F. MOSELEY

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With 376 Illustrations in Color
And 63 Figures in Black and White

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PREFACE

This Atlas of Musculoskeletal Exposures has evolved from the years spent in the study of shoulder lesions and the attempts to record the knowledge so gained in the written word as well as in the still and the moving visual media The author has concluded that the best method of teaching detailed knowledge on subjects relating to the bones and the joints is first to superimpose graphically, layer by layer on the skeletal framework, the various anatomic structures of the region under study and then to illustrate the exposure of the essential lesions from superficial to deeper planes as carried out in surgical operations All possible exposures and the variations necessitated by particular lesions were not encompassed in this undertaking, but it should be possible for the surgeon to work out any relations in point from the plates illustrating the anatomic build-up of a particular region Where possible, and advantageous, the anatomic structures are presented in the positions in which the surgeon tends to view them when postured for surgical procedures This arrangement has been found to be more helpful than illustrating routinely in the anatomic position Further, the illustration and the description may go on to detail certain procedures or even to illustrate one of the conditions for which the exposure was employed The script describing such illustrations serves to correlate the theoretical with the practical considerations and to indicate the various points in order of relative importance

No claim is made for any originality of this method, as it was employed by my former teacher the late Professor J Ernest Frazer, whose work *The Anatomy of the Human Skeleton* remains a classic of the accurate use of this system Nor is originality claimed for any of the exposures included in this volume The student of surgical literature knows well the many authors whose life work is crystallized in the procedures in current use today All surgeons however will agree that a great debt is owed Professor A K Henry for his stimulating work *Extensile Exposure Applied to Limb Surgery*, Dr T Nicola, and, very recently, Doctors Banks and Laufman for their excellent works in this field

The great advance in the visual media has been the gradual advent of color into the still and the motion picture, into the illustration of books, and into the field of television We have had the benefit of the use of color in this work and it is felt that this advantage, together with the method employed, gives merit to the publication of this volume For the greater part, color is used as a teaching aid and in no way attempts to convey the true appearances found in the living patient Those who have studied colored photographs of operative procedures will recognize the great advantage for teaching purposes of the colored drawing over the colored photograph

The plates have been carefully prepared with the closest co-operation between artist and author Dissections in the anatomy laboratory and the autopsy room, operative procedures on the living patient, still and motion-picture photography, roentgenography and on-the-spot sketching by the artist have been the basis of this work

In addition, a short coverage of the local preoperative preparation of the limb and a photographic representation of the posturing of the patient for the various exposures have been added in the hope that they will assist the surgical intern staff Points of surgical technic to promote rapid healing and to ensure scars of good cosmetic value were also regarded as worthy of note.

The author and the artist hope that the contents will assist others in the understanding and the performance of these standard exposures The scope and the detail should be adequate for most purposes Those who have labored to produce this book are fully aware of its limitations.

H F. MOSELEY, D M

Montreal, P Q

ACKNOWLEDGMENTS

The completion of any enterprise brings in its train a series of mixed feelings: there is the feeling of relief at a task completed, which is short lived; there are the fears and the anxieties when one considers all that might have been done to make the effort more valuable, which may persist some time; and there are the feelings of fulfillment of a purpose and of achievement which are associated with an acute consciousness of gratitude and indebtedness to all who co-operated to make the final result possible. Such have been the author's reactions at this stage. This volume represents a mutually co-operative effort on the part of artist and author. Each step and stage have been cross-checked the one by the other, and in all steps and stages they have been assisted greatly by a number of good friends.

The author wishes to acknowledge the collaboration of Dr. Edward J. Tabah, of the Neoplastic Service, and Dr. John A. Drummond, of the Plastic Service, in the dissections, the drawings and the arrangements for draping in the section dealing with the face.

The posturing and the draping for the operative procedures on the trunk have been supervised by Doctors Richard G. B. Gilbert and André F. Pasquet, Consulting Anesthetists to the Montreal Neurological Institute, and follow the routines used in the operating theaters of that Institute. Valuable advice on neurosurgical problems has been given the artist and the author on the plates illustrating exposures of the different regions of the vertebral column by Doctors Arthur R. Elvidge and William V. Cone, of the Montreal Neurological Institute.

Acknowledgment must be made to Paul Hoeber, Inc., who permitted me to draw heavily for Chapters 2 and 3 dealing with the clavicle and its articulations and with the shoulder, from my monograph *Shoulder Lesions*, with which this new work is complementary.

We would like next to record our happy relationship with Dr. R. M. Watrous, Medical Editor, and Mr. J. S. Dunham, Executive Editor, of Abbott Laboratories, with whom we have completed *An Atlas of Shoulder Dislocations* and *An Atlas of Surgical Exposures for Common Fractures of the Extremities*. From these works, 30 color plates have been taken for inclusion in this volume, and it is a pleasure to acknowledge the excellence of the engravings produced from the original art work.

Our gratitude extends to Dr. J. H. Walton, Medical Editor of the Ciba Symposia, and to Mr. Paul Roder, of Ciba Pharmaceutical Products Inc. They have made available 5 beautiful plates in color by Dr. Frank Netter which appeared in our 3 symposia *Disorders of the Shoulder*, *Disorders of the Hip* and *Disorders of the Knee*.

The color plates depicting the detailed anterior and inferior exposures of the shoulder, which appeared in the *Compendio Medico*, published by Sharp and Dohme, have been provided by Mr. E. M. Saravia of that Company.

All anatomic dissections have been executed in the Department of Anatomy of McGill University. The author wishes to thank Professor C. P. Martin, who afforded us the facilities of his department, and also Dr. S. M. Banfill, who provided assistance and advice on certain anatomic points. We are also indebted to McGill University for a grant which, with the generous assistance of the J. B. Lippincott Co., made possible 31 of the color plates.

The photographic work on posturing and draping has been done by Messrs. Harold Coletta and Charles Hodge. The nursing supervision for this part of our project was contributed by Miss Mary Warnock, Miss Betsy Harper, Miss Betty Markham and Miss Margaret Haggart, of the operating-room staffs. Successive residents and assistant residents in general and orthopedic sur-

gery have assisted in this work and acknowledgment is made to Doctors C R Hope, M D Charendoff, Leon Heller, D J Currie and W M Douglas

The manuscript was carefully prepared by Mrs Max Slapack and the references by Mrs F D Peart Medical Librarian at the Royal Victoria Hospital

Finally, my gratitude extends to our publisher, who has brought all our efforts to a happy conclusion

H F M.

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PLATES IN COLOR

I

GENERAL CONSIDERATIONS

I

GENERAL CONSIDERATIONS

INTRODUCTION

The word *exposure* may be used in the active or the passive sense In the former, it denotes the act or means of gaining access, whereas in the latter it connotes the surface or area laid open to view

The word *approach* can also be employed in these two senses and means the act of drawing near or the path or avenue of access, respectively These words are used synonymously in relation to operative procedures on bones and joints, and will be so utilized in the text, since we are endeavoring to describe not only the act of reaching the bone or the joint and the actual area of these parts made available for surgery, but also the relationships of the anatomic structures which constitute the avenue or path itself Indeed great stress will be laid on the anatomic considerations necessary to give facility of surgical exposure and on the important structures, such as nerves and blood vessels, which must be protected and preserved if unnecessary complications are to be avoided It has frequently been stated that "a good anatomist is often a timid surgeon," and there may be a modicum of truth in this statement Probably it would be preferable to state that a surgeon possessing detailed anatomic knowledge is rather careful in dissecting among structures essential for perfect function of the part and for the welfare of the patient He may not impress as does the "natural" surgeon who without such knowledge and with misplaced confidence, does the operation and hopes for the best The improvement in the standard of the surgery on the musculoskeletal structures is due to the greater number of surgeons who are gaining understanding of the underlying anatomic relations It is hoped that the study of the pages which follow will assist the evolution of this progress

PREOPERATIVE PREPARATION

Uncomplicated recovery following operative exposures of bones and joints depends on many factors, all of which are of the greatest significance The first link in the chain of events is the preoperative evaluation and preparation of the patient Both general and local factors must be considered To what avail is a demonstration of operative dexterity if the patient dies as the result of failure to assess the operative risk or to arrange for the appropriate care of shock attendant on major injuries? Or what is the gain from a perfect plating of a bone as judged by radiologic examination if suppuration, resulting from failure to recognize a pyogenic infection in an adjacent area or from faulty skin preparation, ensues in the postoperative period?

The general health of the patient and his ability to withstand the shock of an operation must be investigated carefully in the preoperative period The life of the patient takes precedence over the functional improvement to be derived from elective operations In cases in which exposure of bones and joints is considered to be essential for life and the subsequent function of the limb, the operative risk involved must ever be dominant in the surgeon's mind Although the diabetic patient who is well controlled and stabilized on insulin can withstand operation and go on to good healing this metabolic derangement must always be a deterring factor in deciding upon operations on the skeletal structures The incidence of infective processes is higher in diabetics and more serious since in such cases the presence of metallic plates, screws prostheses and unab-

sorbable sutures in the wound may lead to serious complications Infection of bones and joints resulting from operative procedures is to be dreaded, as it has always been, in this day of increasing bacterial resistance to the antibiotic drugs

PREPARATION OF THE OPERATIVE AREA

The condition of the skin of the operative area should be examined carefully on the patient's admission to hospital Any pyogenic infections must be cleared before elective procedures Abrasions, areas of dermatitis or any lesion likely to interfere with wound healing should be evaluated In the lower limb, the greatest care should be taken to eliminate fungus infections in the interdigital clefts and infections round the nails In this part, the circulatory status is of the greatest importance The presence of varicosities with dermatitis, ulceration, the concomitant edema and lymphatic involvement must all be taken into consideration Operations should be avoided on the distal parts of the lower limbs in cases of circulatory insufficiency The presence of the dorsalis pedis and the posterior tibial pulses is essential to satisfactory healing after operations on the foot When possible, operations on the feet should be avoided in the aged

Once operation is decided upon, the area concerned should be subjected to careful preparation, extending in elective cases over a 48-hour period This is often referred to as an *orthopedic preparation* However, because of the excellent blood supply and rapid healing in the case of the face and the neck, preparation on the day of the operation suffices for these regions

The hair is shaved from the region of the proposed operation for a variable distance Because of the cosmetic factor and the possibility of irregular growth, the eyebrows should be left untouched, if possible The area of skin preparation for the different parts is illustrated and detailed in the respective sections which follow It is better to err on the side of too wide rather than too restricted an area In the case of the extremities, the nails are pared short and cleared mechanically of debris, and the cuticles and the interdigital clefts are cleansed Calloused skin should be softened with detergents and scrubbed For operations adjacent to the trunk, the shaving of the axilla, the pubis and the perineum is most important Following the shaving, a bath is ordered for the patient, if this is possible, and also a local cleansing of the shaved part

Articles on Shaving Tray

Tray Covered with a Paper Towel

1 Treatment rubber and towel cover
2 Razor and sharp blades
3 Bowl of hot water
4 Flask of green soap
5 Can of pledgets
6 Kidney basin
7 Swab sticks
8 Flashlight or droplight

Method

1 Protect the bed with rubber and towel cover

2 Apply green soap and water to skin with pledgets, making a lather

3 Shave the skin to meet the requirements of the operation

4 Avoid nicking Report any breaks in skin to the nurse in charge

The actual local preparation in the ward after shaving varies in different centers, but the following serves as an example

Sterile Tray Containing

3 solution bowls
1 large kidney basin
2 artery forceps
Sponges
Dressings
2 dressing towels
2 orthopedic drapes
2 bandages, 2 inch or 3 inch
Sterile water
Green soap or detergents such as pHisoHex or Germa-Medica
Ether
Alcohol

METHOD

1 Using artery forceps, scrub the area very carefully with green soap or detergent and sterile water Rinse with sterile water

2 Using artery forceps and pledgets, apply ether to the area and allow to dry

3 Using artery forceps and pledgets, paint the area with alcohol and allow to dry

4 Wrap the area in sterile towels and *bandage securely* No adhesive or pins should be used to hold the towels in place

5. Repeat this preparation twice daily for 2 days and on the morning of the operation Some surgeons are content with two such preparations of the area

ARRANGEMENTS IN THE OPERATING ROOM

In an operation on an extremity the first decision to be made is whether it is best performed in a bloodless field This is readily arranged for either limb beyond the mid-point of the arm or the thigh by applying an Esmarch bandage and pneumatic tourniquet

The limb, with its sterile preparation still in place, is elevated for 2 or 3 minutes to drain the blood from it The pneumatic tourniquet is arranged at the most proximal point possible A rubber bandage is wound firmly round the limb from distal to proximal parts It is tied at the lower level of the tourniquet, which is then inflated to a point which completely obliterates the pulse The pressure required naturally varies with the age, the muscular development and other factors, and for the upper limb it may vary from 5 to 10 pounds and for the lower extremity from 10 to 15 pounds of pressure The Esmarch bandage is removed

The next step is the posturing of the patient for the particular exposure required This is depicted for the various regions in photographs in the chapters which follow

The towels and the bandages which were applied in the ward are now removed, and the limb is supported by the orderly while the final skin preparation is made by the assistant

Here again there will be differences in arrangements in the individual institution Two alternative scrub-ups are given as examples

Preparation 1	*Preparation 2*
pHisoHex or Germa-Medica	Spirit of soap (green)
Sterile water	Sterile water
Tincture of iodine 2½ per cent (some prefer 5 per cent)	Tincture of iodine 2½ per cent (some prefer 5 per cent)
Alcohol 60 per cent	Alcohol 60 per cent

Method

1 The area indicated for the particular exposure is cleaned with the detergent or green soap, which is finally rinsed off with sterile water

2 Tincture of iodine is swabbed over the area Care is taken to avoid puddling or concentration in any area This might cause burns The painted area and the periphery where any burns might be expected are swabbed with alcohol

3 The limb, still supported by the orderly and now prepared, is ready for draping

DRAPING THE PATIENT

In addition to the great value of preparing the skin and posturing the patient, the method of draping affords another important link in our chain of events In the sections which follow, each exposure will have the steps for the posturing and the draping illustrated However, it will be well at the outset to describe the system generally This can be done for the knee, and the points concerned can be correlated for the other regions Figure 1 illustrates these steps We shall presume that the patient is to have an anterior exposure of the knee joint

In A the patient is shown postured in the supine position on the operating table

In B. the orderly supports the limb by the toes If a bloodless field is desired. the appropriate steps are taken and this is followed by the skin preparation. The foundation sheet is placed beneath the limb and over the opposite extremity

In C, a towel has been clipped round the lower thigh to delimit the field superiorly The foot and

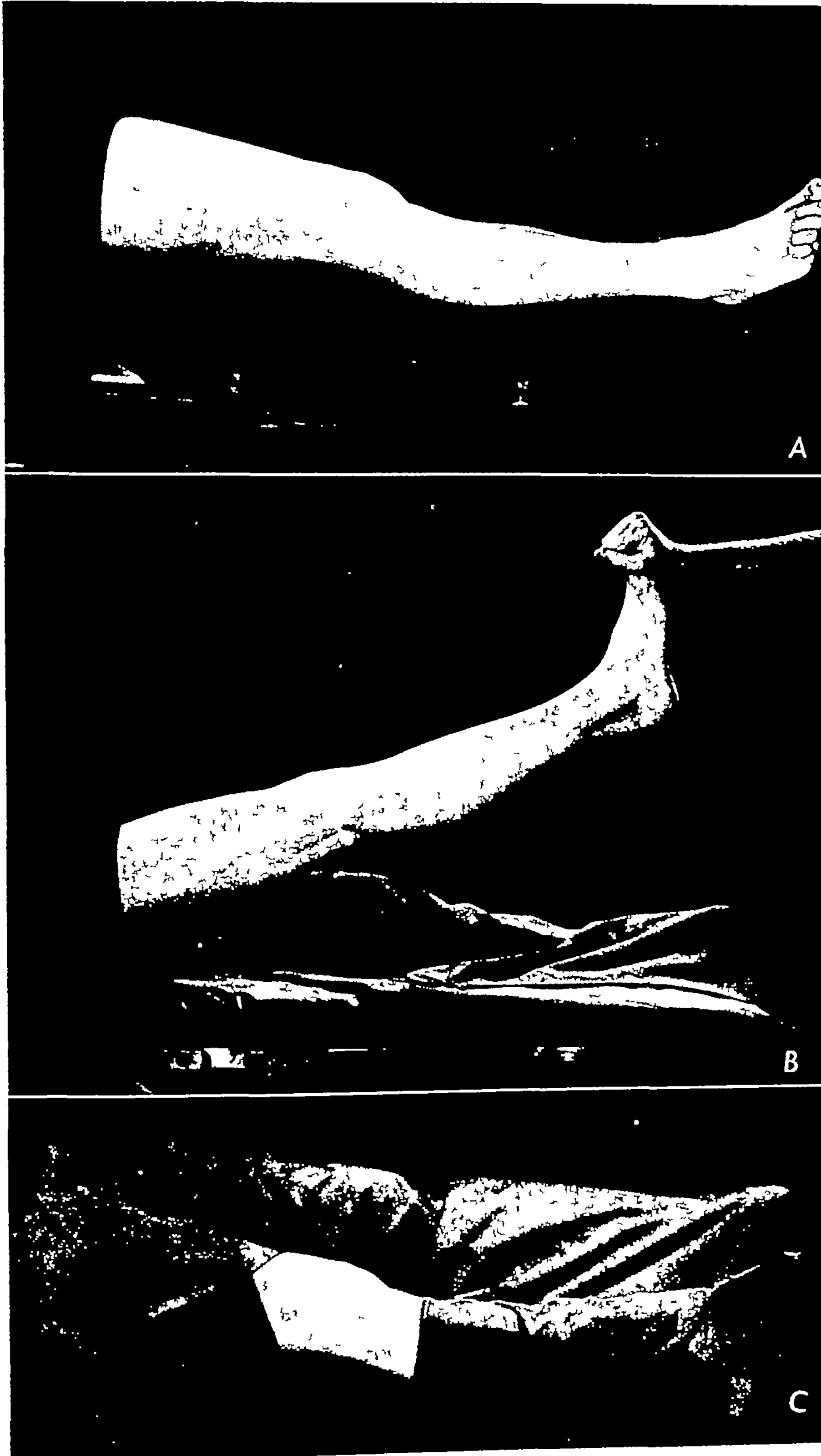


FIG 1 Posturing and draping for anterior exposures of the knee

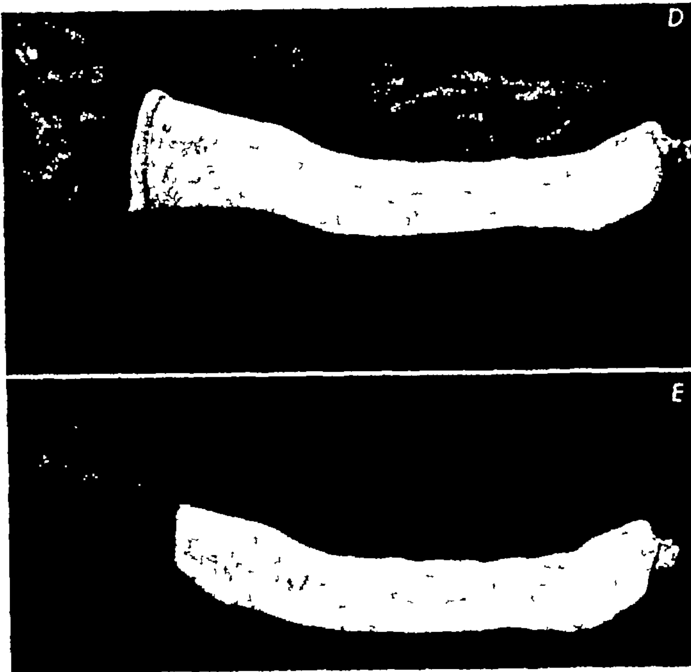


FIGURE 1 (*Continued*)

the leg have been received into a sterile towel, which is held in place by clips

Figure D shows the stockinet rolled over the limb to the upper limit of the field

Figure E completes the series, as the limb has been passed through the opening in the laparotomy sheet, which is used as a coverall The opening has been narrowed and secured by a clip at the upper limit of the operative field

We are now ready for the operation to begin

NONTOUCH TECHNIC

"I will now relate the several steps which are involved in an operation for simple fracture I will do so in some detail, *as apart from manual dexterity and skill the whole secret of success in these operations depends on the most rigid asepsis* The very moderate degree of cleanliness that is adopted in operations generally will not suffice when a large quantity of metal is left in the wound To guarantee success in the performance of these operations the surgeon must not touch the interior of the wound even with his gloved hand, for gloves are frequently punctured, especially if it be necessary to use a moderate amount of force, and the introduction into the wound of fluid which may have been in contact with the skin for some time may render the wound septic All swabs introduced into the wound should be held in long forceps and should not be handled in any way

"The operator must not let any portion of an instrument which has been in contact with a cutaneous surface or even with his glove enter the wound

"After an instrument has been used for any length of time or forcibly it should be resterilized

"No germicide or other fluid should be introduced into the wound

"Having made the incision the patient's skin is completely excluded from the wound by securing the margin of a sterile towel to each edge of the incision

"Ligatures or sutures are never used, so avoiding the risk of introducing the hand into the wound "[5]

The author has preferred to quote directly, from the original text, some of the principles laid down by Lane, to whom credit may be given for the introduction of the nontouch technic and also the special instruments still in constant use today, which make such aseptic technic possible However, those who have observed the surgery of bones and joints in different parts of the world will realize that, so far as aseptic technic is concerned theory is in advance of practice

Nontouch technic is the ideal toward which we must all strive Our degree of success in its application will be relative—relative to the environment in which we practice There is no comparison between the clinic with a team working together for prolonged periods, where a rigid ritual for operations is carried out with ease, and the teaching hospital, where at every operation one or more members may be part of the team for the first time This factor is even more dominant in the outlying hospitals where, for the most part, assistants may be untrained in operative work

It must also be remembered that the nurses in the operating room as well as the surgeon and his assistants are part of the team in every operative procedure, and the aseptic technic is the product

[5] Lane, W A "Operative Technique" *in his* Operative Treatment of Fractures, ed 2, pp 126-136, London, Medical Publishing Co, 1914.

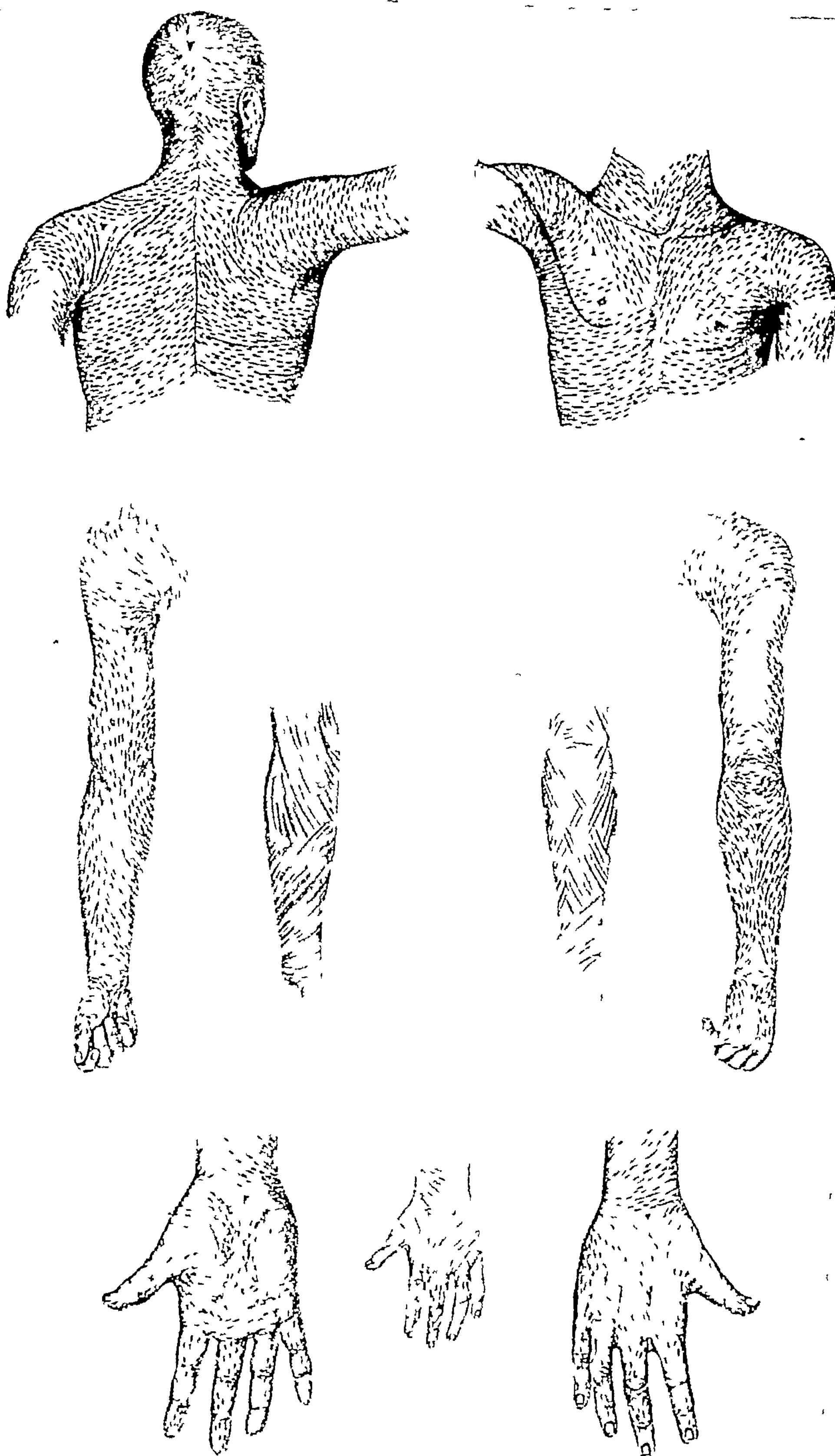


FIG 2 Langer's original illustrations for the upper extremity (Langer, K Zur Anatomie und Physiologie der Haut, Sitzungsber d k Akad d Wissensch Wien, 1861-1862)

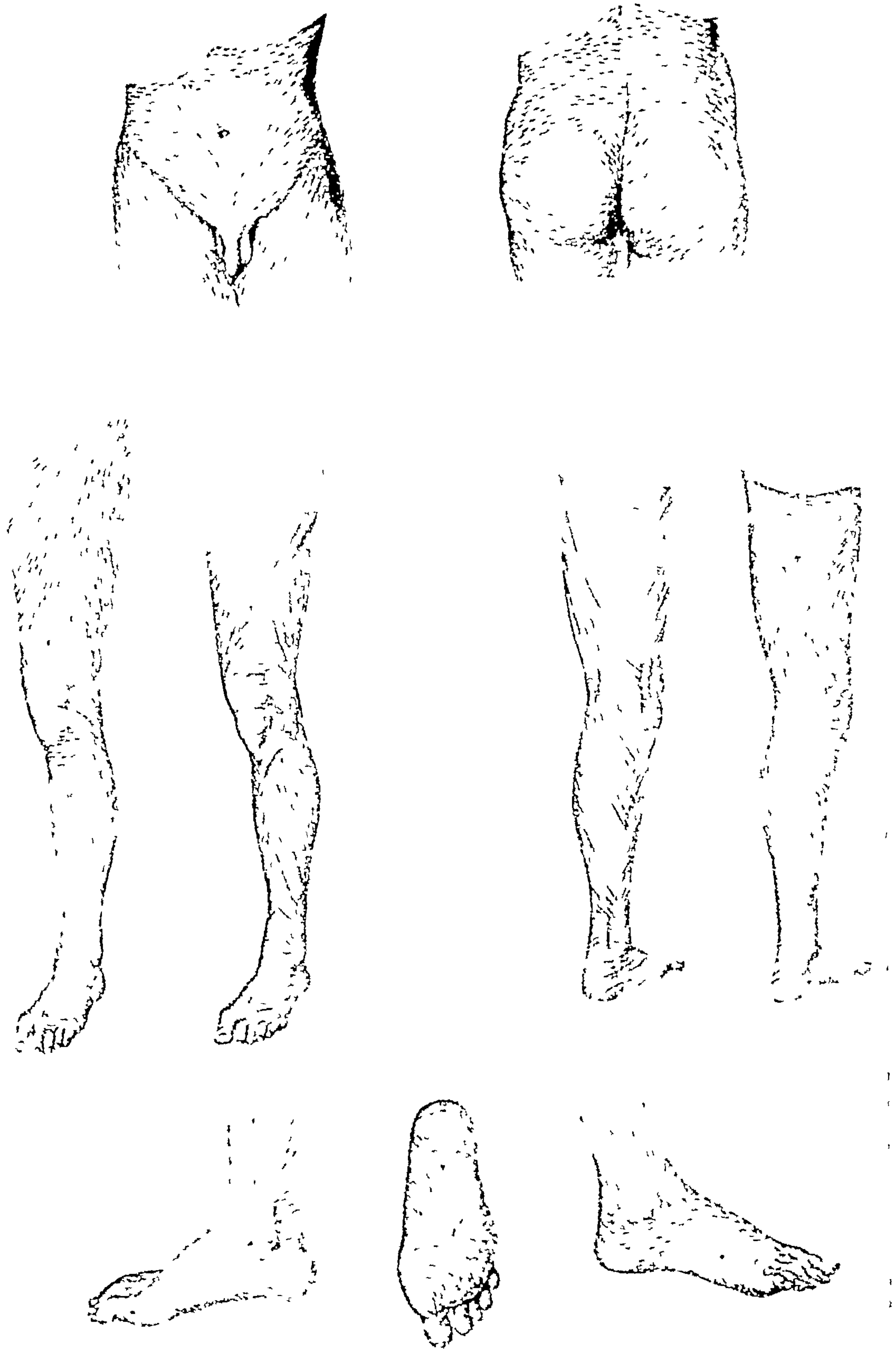


FIG 3 Langer's original illustrations for the lower extremity (Langer, K : Zur Anatomie und Physiologie der Haut, Sitzungsber d k Akad. d Wissensch Wien, 1861-1862)

the combined effort The errors that creep in due usually to the weaker links in this chain l not to the surgeon, who is held responsible Clean bone cases must not be posted in operat- rooms to follow septic or dirty cases Com- :ations are inevitable in such an environment e advantages of the rubber glove, for which we indebted to Halsted, should not lull us into a se of false security And it will not, if investi- ions such as those of Weed and Groves are died and we remember that in 75 per cent of rations defects in gloves may be found

The nontouch technic should be the most im- tant link in our chain of events to secure un- nplicated recovery

SKIN INCISIONS

Refinement in technical detail is coming into in the operative procedures on bones and its Unsightly scars from operations on the ex- nities denote a lack of surgical skill They are chological handicaps in females and constitute economic problem for those employed in the ertainment world

Attention to the direction of the skin incision to iform with Langer's lines (Figs 2 and 3) and h the wrinkle lines will improve the cosmetic pearance of the resulting scar In relation to the cor aspect of joints, the longitudinal incision st be avoided and replaced by the zigzag type e "pernicious median longitudinal" incision the fingers should not be employed In each tion some of the accepted incisions will be istrated

The length of the incision should be the mini- m required for the procedure in hand This ist be judged by the eventual depth of the und and the extent of the bone or the joint ich must be visualized The length must be ade- ate to obviate the necessity of excessive retrac- n of muscles, nerves and blood vessels Cutane- s nerves must be preserved wherever possible, eir partial or complete division results in ublesome anesthesia, paresthesia or painful uroma formation

DEEP DISSECTION

Where possible, the deep dissection should follow the fascial interspaces between muscles Where necessary, muscles are split in the direction of their fibers or are reflected subperiosteally The nervous and the vascular supply of muscles must be carefully preserved Nerves and vessels must be retracted with great gentleness, and elastic retraction is probably best

Where possible, the periosteum should be preserved intact This is especially true when the fractured ends of bone are being exposed Excessive stripping is unnecessary and removes one source of blood supply to the healing area

Incisions into joints should be made in such a way as to preserve all ligaments important to joint stability

WOUND CLOSURE

The suture of wounds following exposures of bones and joints demands the greatest care A great deal can be learned from the application of the technical details employed by the plastic surgeon The finest sutures that will achieve the purpose required should be used Whether the surgeon follows the school of silk or other unabsorbable suture technic or the school of catgut technic, the underlying principle is tissue approximation with the minimum of tension The closure of the deep recesses of the wound, with anatomic restoration of the displaced structures, should obliterate all dead spaces and thus prevent hematoma formation It is best to avoid drainage

Lessening of the final width of skin scarring can be achieved by the routine use of interrupted subcuticular sutures of No 40 wire which remain *in situ* permanently

DRESSINGS

The wound should be protected by an evenly applied absorbent dressing The use of a petrolatum or Zeroform gauze directly over the wound facilitates the first change Pressure is valuable

after operations on the hand and the knee when a bloodless field has been arranged for the operation Plaster-of-Paris splintage will be employed when necessary and applied with careful padding of all pressure points

POSTOPERATIVE MEASURES

After all operations, but especially after those involving the face and the neck, careful observation is essential to maintain a proper airway Deep breathing exercises are important The spinal wounds are best protected by posturing the patient on either side and on the face with routine timed turning The extremities, after operation, are elevated for from 24 to 48 hours to diminish the tendency to reactionary and hypostatic edema Movements of the muscles of the lower limb are encouraged to minimize the tendency to venous thrombosis For the lower limb, a cradle will afford protection from pressure An ice bag will lessen pain in many instances

Analgesics for pain and sedatives to relieve anxiety and secure sleep are given

After major exposures of bones and joints the protection afforded by antibiotics should be routine

CONCLUSION

Each link in the chain of events necessary to secure uncomplicated recovery after operative exposures of the bones and the joints is essential Complications develop in proportion to our failure to apply the necessary principles in practice These have been outlined briefly in the preceding paragraphs

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2

THE FACE

2
THE FACE

INTRODUCTION

The bones of the *face* and the *temporomandibular joints* are exposed for a variety of operative procedures Increasing specialization has demarcated the face as a regional specialty largely in the domain of plastic, faciomaxillary, and head and neck surgeons This arrangement is due to the necessity of obtaining the best cosmetic result, which entails meticulous technic, carefully planned incisions, soft-tissue flaps and complicated reconstructive procedures In times of war there is a great increase in the number of cases requiring major surgery in this region In civil life, the majority of cases is derived from

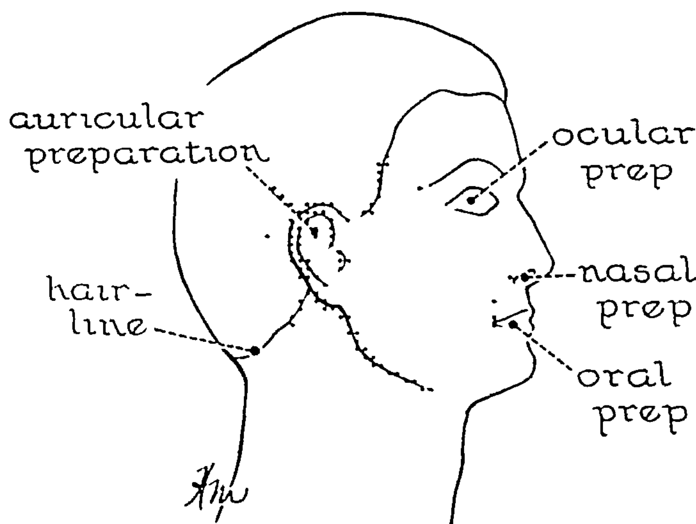


FIG 4 The area of skin preparation for operative procedures on the malar bone and the temporomandibular joint is approximately that indicated here

The shaving of the hair should extend upward for approximately 2 inches above the hairline in front of the ear and above and behind the pinna for approximately 1 inch The eyebrow should not be shaved For the indirect approach to the malar bone by Gillies' method, the skin preparation should extend on to the nose This is not required in exposure of the temporomandibular joint Careful attention is given to ocular, nasal, oral and auricular preparations

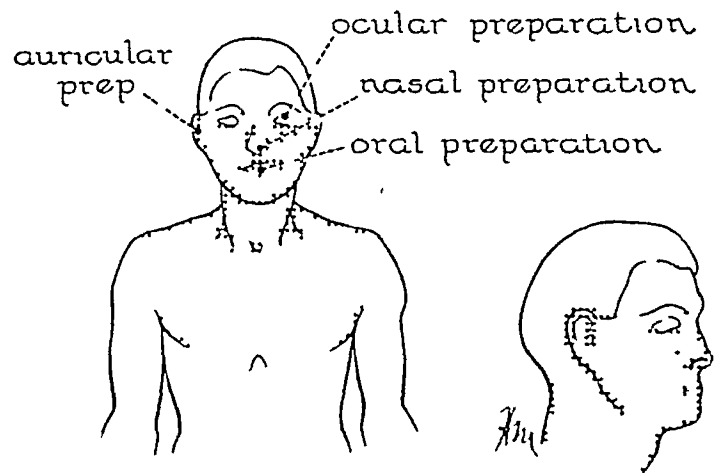


FIG 5 Area of skin preparation for operative procedures on the mandible and the malar, the maxillary and the nasal bones

The first decision that must be made in the preoperative period is whether any operations to be performed will be associated with incisions on the neck, such as a combined operation on the mandible with block dissection of the cervical lymph glands If this is required, the operative area should extend from the level of the orbits to the nipple line, with shaving of the upper chest if necessary When extension to the neck is not indicated, the field will be delimited accordingly Care is given the preparation of the external ear, the eye, the nose and the mouth The lateral view shows the posterior limit of the area of skin preparation



FIG 6 Posturing and draping for operative procedures on the malar bone and the temporomandibular joint

(*Left*) The patient is postured in the supine position with the head turned to the opposite side The foundation sheet covers the patient from the upper neck to the toes, and the head is enclosed in a towel clipped so as to expose the ear, the nose and the full lateral aspect of the face

(*Center*) A 4-towel draping of the operative area is then arranged The upper towel is placed as for the Gillies' elevation of the malar bone, the anterior portion of which the surgeon must be able to see and palpate for position The exposed area can be further delimited anteriorly and superiorly for operations on the temporomandibular joint

(*Right*) The laparotomy sheet is then applied with the opening closed to the size required for the procedure in hand

transport accidents or from the radical surgery necessitated by neoplastic disease in the mouth and its environs

The *zygoma*, the *maxilla*, the *nasal bones* and the *mandible* are superficially placed and are readily accessible from the cutaneous or the mucosal surface Often a combination of both avenues of approach is necessary When possible, incisions on the skin surface are avoided, although it is evident that there is a greater tendency to infection if procedures are carried out through the oral or associated cavities

The *temporomandibular joint* is subject to mechanical derangements and infective processes which necessitate operative correction to ensure proper function In these cases the services of an orthodontist are often required on the problem of occlusion

The exposures to be covered in this section are those most commonly required for traumatic, infective and neoplastic disorders, together with various secondary reconstructive procedures They are intended to serve the general, the traumatic and the orthopedic surgeons who may be required to treat such cases

PREPARATION OF THE OPERATIVE AREA

It has been stated in Chapter 1 that the preparation for operative procedures on the face and the neck differs somewhat from that for the trunk and the extremities The excellent blood supply and healing qualities enable the surgeon to dispense with the prolonged preparation, extending over 48 hours, often required in the case of the trunk and the extremities Certain particular



FIG 7 Posturing and draping for operative procedures on mandible and cervical region
This figure and the one following afford suggestions for posturing and draping when the mandible with the neck will be the region for operation This arrangement is suitable for a local operation on the ramus of the mandible and unilateral dissection of the cervical lymph nodes
(*Left*) The patient is postured in the supine position with the head turned to the opposite side The foundation sheet covers the body from just below the clavicle to the toes The head is enclosed in a towel fastened to leave the mandible and the ear exposed
(*Center*) The 4-towel draping of the operative area is arranged to suit the operation planned
(*Right*) A laparotomy sheet is applied with the opening framing the area required

points, however, must be remembered in the preoperative preparation of this region

The Eye

Care must be taken to note the presence of any infectious or other disorder of the lids or the eyeball At the time of operation, a drop of mineral, olive or castor oil is instilled into each eye and the closed eyelids are covered with a pad Solutions used for skin preparation and for inhalation anesthesia such as chloroform or ether, must not enter the conjunctival sac

The Nose

The nasal passages must be cleansed with cotton pledgets soaked in a mild antiseptic

The Ear

The pinna and the external auditory meatus should be cleansed mechanically of debris and swabbed with a solution of green soap and water A small plug of cotton soaked in a mild antiseptic can then be inserted into the external auditory meatus

The Mouth

Prior to the operation, the teeth and the gums are brought to the best possible condition as regards cleanliness The mouth is washed out with a mild antiseptic solution When necessary, the tongue is scraped of debris Any dehydration should be corrected by attention to the electrolyte balance which, combined with oral hygiene will constitute the prophylactic measures against postoperative parotitis



FIG 8 Posturing and draping for operative procedures on the entire mandible and neck
The steps follow those for Figure 7, except that in this instance the operation is planned to approach the mandible on both sides and to include bilateral block dissection of the cervical lymph nodes Therefore, the toweling of the head exposes the mouth and the whole mandibular area
The head can be turned from side to side as necessitated by the stages of the operation



FIG 9 Posturing and draping for operative procedures on the malar, the maxillary and the nasal bones
The steps follow those for the other facial bones, but the draping delimits a smaller area and leaves the nose, the mouth and the eye exposed, depending on the requirements of the case With such arrangements the oral elevation of the malar bone or the various manipulations of the nasal bones can be performed The draping shown is especially designed for resection of the maxilla

The Eyebrows

When at all possible, the eyebrows remain unshaved because of the cosmetic factor and the tendency to irregularity in the regrowth

The Scalp

The hair and the scalp must be examined in the ward for the presence of parasites, impetiginous dermatitis, acne or boils Parasites such as the *Pediculus capitis* should be completely eliminated, and infections should be cleared before operation is undertaken For those procedures which involve the face, a limited area only will require to be shaved

Antiseptic Solutions

Most surgeons prefer the use of colorless antiseptic solutions for the skin preparation Strong solutions are seldom required

ARRANGEMENTS FOR ANESTHESIA

In the posturing and the draping one must take into account the requirements of the anesthetist Some of the procedures are carried out under local anesthesia, but many major operations require general anesthesia with endotracheal intubation The airways and the apparatus must be arranged carefully before the final posturing, skin preparation and draping

PLATE 1

Relations of the Temporomandibular Joint

The *temporomandibular joint* is formed by the articulation of the condyle of the mandible with the mandibular fossa and the articular eminence of the temporal bone An intra-articular fibrocartilaginous disk divides the joint into superior and inferior cavities which may communicate through a central perforation in the meniscus

The joint can be localized readily in the living patient Inspection reveals the condyle moving forward as the mouth is opened, and backward as the mouth is closed The condyle is noted just below the zygomatic arch, at the level of the external auditory meatus and the tragus of the pinna Palpation will confirm these points, and the forward movement of the condyle on opening the mouth will be felt, because a hollow space develops behind the condyle

This plate illustrates the complex anatomic relations which must be reviewed before exposing this joint and undertaking surgical procedures on it

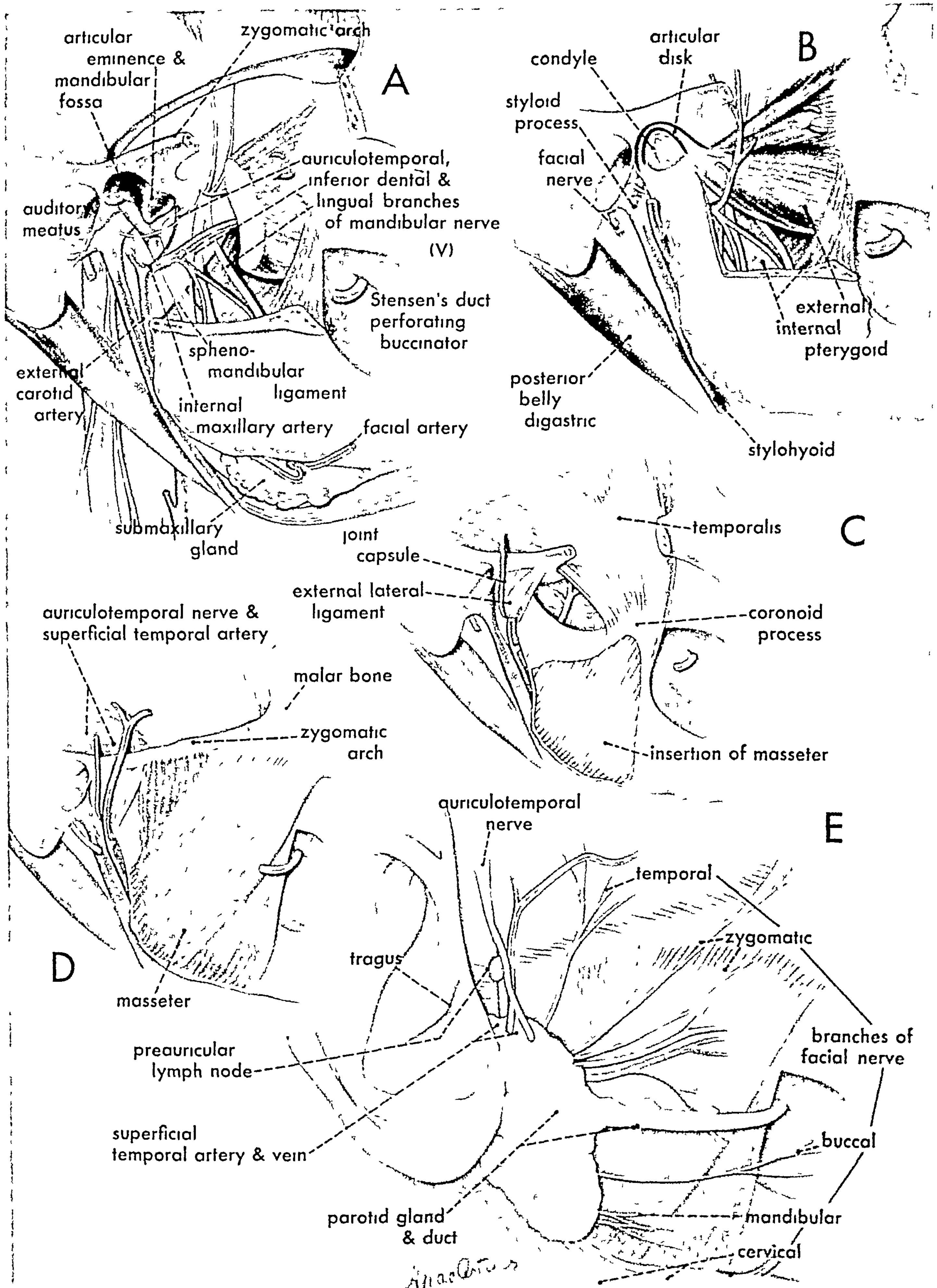
In A, the basic bony structures are depicted First, note the sectioned zygomatic arch, beneath which is the concavoconvex articular surface, situated for practical purposes on a level with the auditory meatus On a deeper plane, the sphenomandibular ligament arising from the sphenoidal spine forms a medial relation of the condyle, while more posteriorly the styloid process and the main trunk of the facial nerve can be seen The internal maxillary artery and the auriculotemporal and other branches of the mandibular division of the fifth cranial nerve should also be correlated. The pterygoid plexus of veins has been omitted for simplicity

Figure B shows the condyle in place The disk has been sectioned in the sagittal plane to indicate that it is thick posteriorly, thin and possibly perforated over the apex of the condyle, and thickest anteriorly where the external pterygoid inserts into it The external and the internal pterygoid muscles are completed, and Figures A and B should be correlated regarding these two structures The course of the auriculotemporal nerve behind the neck of the mandible gives it an intimate relationship to the joint capsule The other major branches of the fifth nerve which are seen in the first two drawings are the inferior dental and lingual branches of its mandibular division

The capsule of the joint and the reinforcing band of the external lateral ligament are added in C, with the auriculotemporal nerve in close relationship Note also the completion of the temporalis muscle with its tendinous insertion into the coronoid process

Figure D illustrates the zygomatic arch overlying the temporalis tendon, from which it is separated by fascial planes and a pad of fatty areolar tissue The masseter muscle, whose insertion on the mandible is indicated in C, is shown in D In close relation to the neck and the condyle of the mandible is the external carotid artery with its division into the internal maxillary and superficial temporal branches These arteries are closely related to the joint and are usually seen in operative procedures on this articulation Note also the styloid process with the stylohyoid muscle arising from it This is the landmark for the trunk of the facial nerve

The complete assembly of the anatomic structures in this area is illustrated in E The relations of the parotid gland, which extends up to the zygomatic arch, the auriculotemporal nerve, the superficial temporal vessels and the preauricular lymph gland to the superficial aspect of the joint should be noted The most important structure, however, is the temporal branch of the facial nerve This nerve, which is motor to the frontalis and the orbicularis oculi, passes in the substance of the parotid gland upward toward the angle of the eye It lies deep to the deep fascia until just above the zygomatic arch, at which point it passes to a more superficial plane Its course is indicated in E, and it should be remarked that only the posterior ¾ to 1 inch along the zygomatic arch is safe for dissection at operation As will be demonstrated in the next plate, this important structure can be preserved by approaching the joint behind this area and protecting it with a barrier of soft tissues It is the structure most commonly injured in operative procedures on this joint, with resultant weakness or inability to close the eye or raise the eyebrow on the affected side



A
articular
eminence &
mandibular
fossa
zygomatic arch
auditory
meatus
auriculotemporal,
inferior dental &
lingual branches
of mandibular nerve
(V)
Stensen's duct
perforating
buccinator
spheno-
mandibular
ligament
external
carotid
artery
internal
maxillary artery
facial artery
submaxillary
gland
B
condyle
articular
disk
styloid
process
facial
nerve
external
internal
pterygoid
posterior
belly
digastric
stylohyoid
C
temporalis
joint
capsule
external lateral
ligament
coronoid
process
insertion of masseter
D
auriculotemporal nerve &
superficial temporal artery
malar bone
zygomatic
arch
masseter
E
auriculotemporal
nerve
temporal
zygomatic
tragus
branches of
facial nerve
preauricular
lymph node
superficial
temporal artery & vein
buccal
parotid gland
& duct
mandibular
cervical

PLATE 2

Exposure of the Temporomandibular Joint with Resection of the Intra-articular Meniscus

The *temporomandibular joint* may require exposure for a variety of disorders Internal derangements caused by lesions of the meniscus, recurrent subluxations and dislocations, chronic dislocations, fractures of the condyle, infectious arthritis, ankylosis from a variety of causes, all may necessitate operation to relieve pain or to improve function

The drawings on this plate illustrate the application of the anatomic knowledge correlated in the preceding plate to the operative exposure of this articulation As previously stated, the most important structure for protection and preservation is the temporal branch of the facial nerve This determines the initial incision and the dissection

Incision Various authors have utilized different incisions Most commonly, a longitudinal incision just in front of the ear is employed Others have joined this with a horizontal incision along the zygomatic arch It has already been indicated that the temporal branch of the facial nerve crosses the arch at the level of the eminentia articularis, allowing only ¾ inch safe for this branch of the incision The line of incision, indicated in Figure A, follows the skin lines adjacent to the ear, passes on the inner side of the tragus and leaves an invisible scar Its length permits ready reflection of an adequate flap of soft tissues

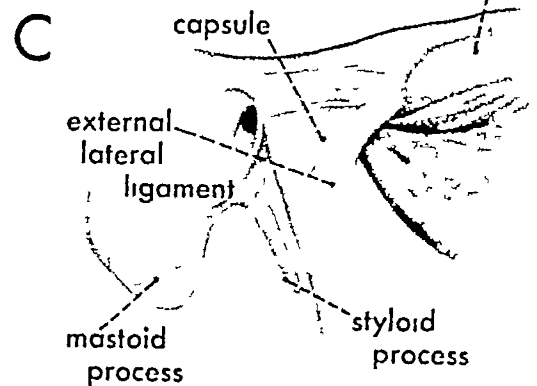
Deep Dissection The incision indicated in A is through the skin and the superficial fascia, which are reflected forward If possible, the deeper incision is placed anterior to the auriculotemporal nerve and posterior to the superficial temporal vessels, which are raised with the anterior flap However, section of branches of these vessels may be necessary The zygomatic arch and the capsule are now exposed, as indicated in B The condyle of the mandible can be palpated just below the zygomatic arch and at *the level of the auditory meatus and tragus* The relationships are reiterated in Figure C Details of the meniscus are shown in D The meniscus has been cut away to indicate how closely the articular disk is applied to the articular cartilage of the condyle The insertion of the external pterygoid tendon into the meniscus and the fossa on the neck of the mandible should also be noted The much greater coronal diameter of the condyle as compared with its sagittal diameter should be understood Figure E reviews the relations of the joint, and the dotted line marks the usual line of section for excision of the condyle and the neck in cases of ankylosis

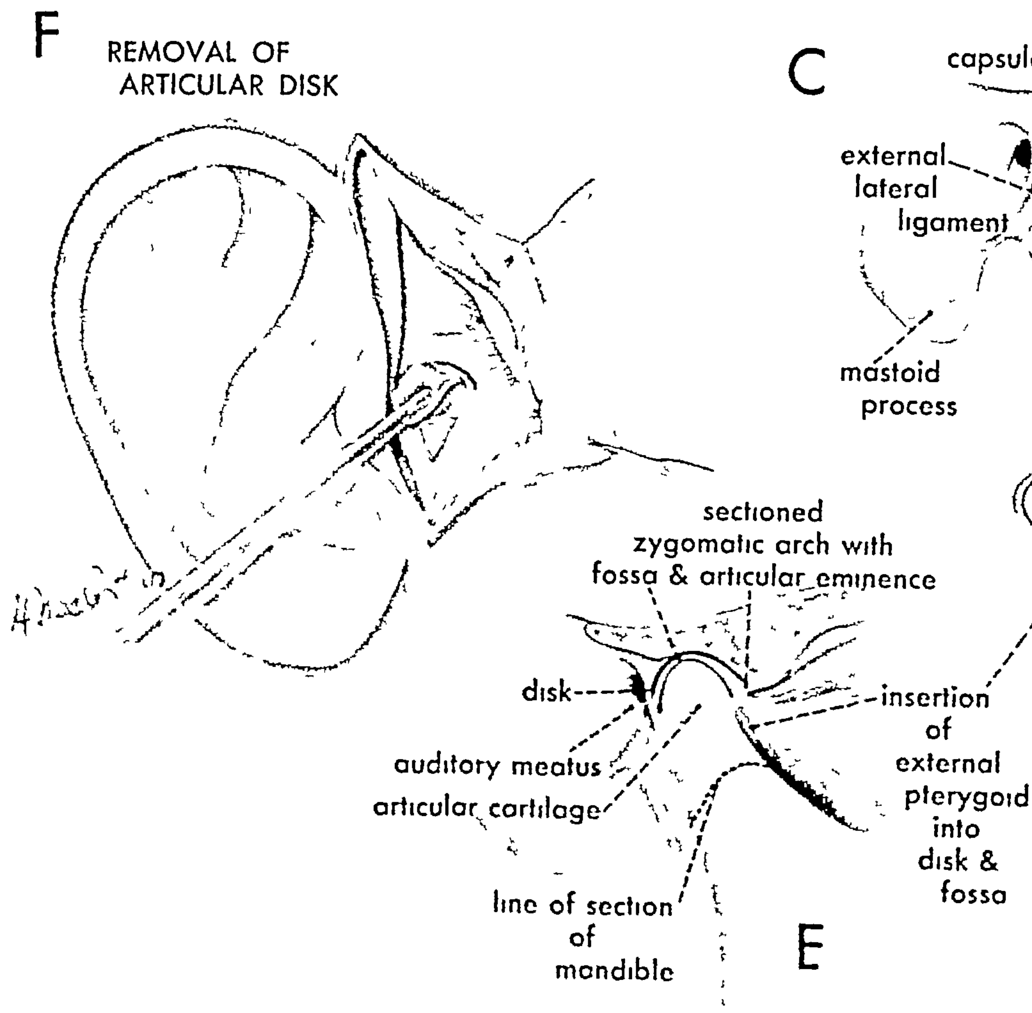
The line of capsular section remarked in B is shown open in Figure F The intra-articular meniscus has been detached laterally along its attachment and anteriorly from the external pterygoid tendon, and is being held forcibly Varying the position of the condyle by opening and closing the jaw facilitates its removal

The exposure can be extended for the various procedures which may be required Wound closure is readily made

line of incision
auriculotemporal nerve
temporal branch of facial nerve
superficial temporal vessels
zygomatic arch
tragus
condyle
A
facial nerve
parotid gland

B
auriculo-temporal nerve
line of section of capsule
zygomatic arch







D
ANTERIOR VIEW OF CONDYLE

PLATE 3

Relations and Exposures of the Mandible

This plate illustrates the anatomic relations and exposures of the right half of the mandible Correlation of this plate should be made with Plates 1 and 2

The *mandible* is prone to disorders caused by trauma, infection and neoplasia Neoplastic processes may be primary in the bone, or secondary involvement may result from carcinoma arising in the oral soft tissues

Infections and cysts of dental origin can usually be approached by the oral route Major resections of the mandible are necessitated by the radical surgery of oral carcinoma Most fractures of the lower jaw are treated successfully by wiring adjacent teeth or by external pin fixation However, nonunion of fractures or large bone defects may require that reconstructive procedures be carried out, in which case the exposures depicted on the plate are useful

Figure A shows the important structures related to this superficially placed bone The masseter muscle covers the ascending ramus and the angle of the jaw The facial artery and the anterior facial vein cross the lower border of the mandible at the anterior margin of this muscle, where the pulsation can be palpated The horizontal ramus marks the base of the submaxillary triangle, which contains the submaxillary salivary gland and the related group of lymph nodes The other two sides of the triangle are formed by the posterior belly of the digastric and the stylohyoid muscles posteriorly and by the anterior belly of the digastric anteriorly The submental triangle lies immediately below the chin, and is bounded by the hyoid bone and the two anterior bellies of the digastric muscles The mylohyoid muscles fusing in the medial raphe form its floor, and the contents of the triangle are the submental lymph nodes The superficial surface of the mandible is covered by a soft-tissue flap, the inferior lip and cheek, which contains the muscles of expression and is lined by the oral mucosa

The skin incision for exposure of the right half of the mandible is indicated Posteriorly, the approach is placed ½ inch below the angle of the jaw to preserve the cervical and the mandibular branches of the facial nerve If it is necessary to expose the whole mandible, the incision can extend in a circle from one side to the other, reaching inferiorly to the level of the hyoid bone

In B, the incision noted in A has been made and the soft-tissue flap turned upward The facial vessels have been ligated and divided, and the superior ends have been sutured over the motor branches of the facial nerve to protect them The horizontal ramus of the mandible is thus exposed

If a more extensive exposure is required, the lower lip is split in the midline, as indicated by the dotted line in B The labial artery is secured The mucosa is sectioned along the gingival reflection backward as required, and the whole flap is turned posteriorly, as shown in D In this drawing, the masseter has been reflected subperiosteally at its insertion and the ascending ramus partially exposed

Details of the submaxillary triangle must be understood for dissection of the inferior border and the deep surface of the mandible The necessary information can be noted in C A fascial plane is easily found by passing a blunt dissector deep to the mandible and keeping close to its surface This separates the superficial portion of the submaxillary gland, which can be retracted outward and posteriorly If the posterior border of the mylohyoid is then retracted forward, the hyoglossus muscle can be seen deeply The deep part of the submaxillary gland with its duct can be located lying on the hyoglossus, with the lingual nerve passing forward above the duct and the hypoglossal nerve running parallel with the duct but below it

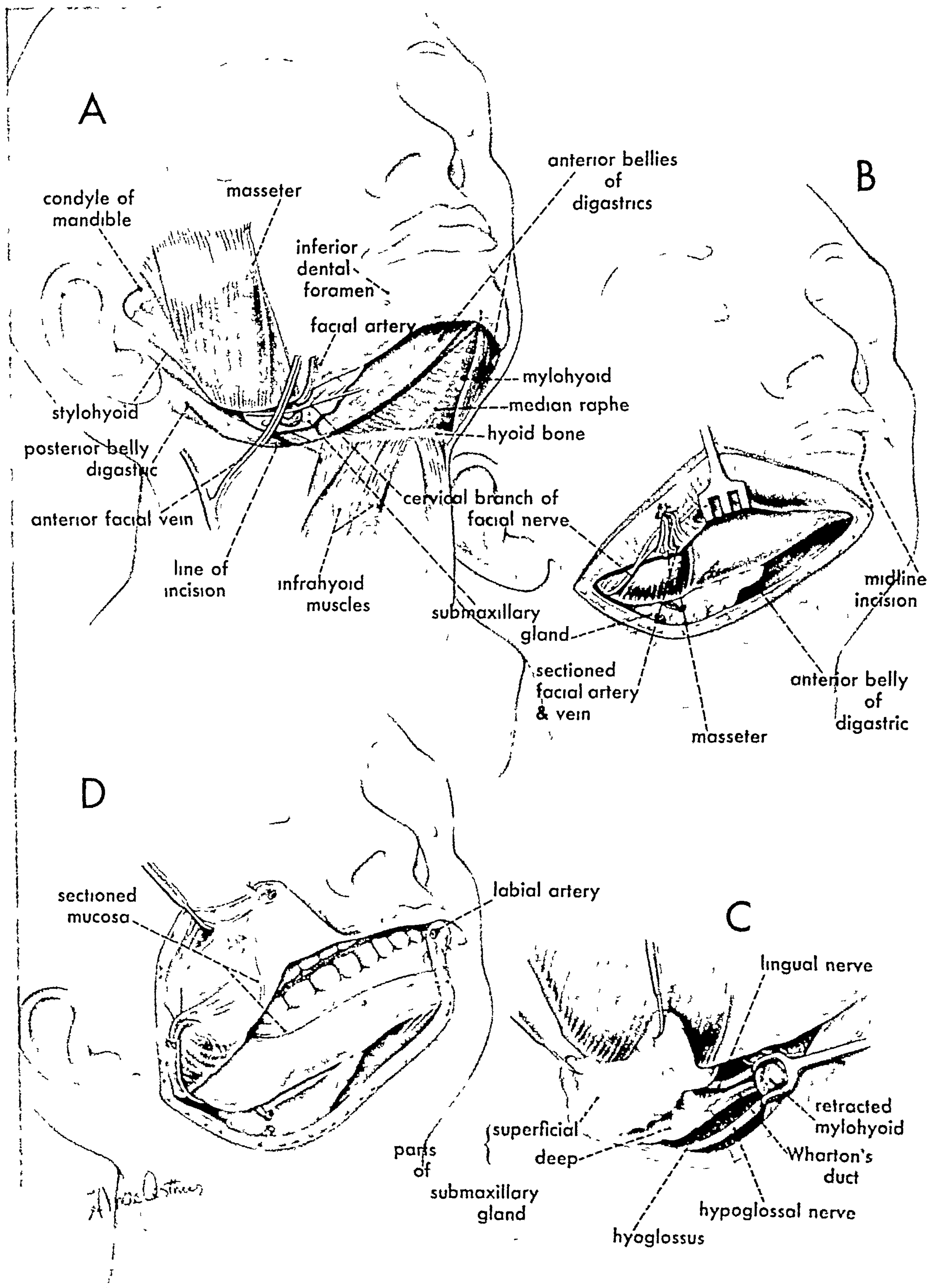

A
condyle of mandible
masseter
inferior dental foramen
facial artery
anterior bellies of digastrics
mylohyoid
median raphe
hyoid bone
stylohyoid
posterior belly digastric
anterior facial vein
cervical branch of facial nerve
line of incision
infrahyoid muscles
submaxillary gland
B
midline incision
sectioned facial artery & vein
anterior belly of digastric
masseter
D
sectioned mucosa
labial artery
C
lingual nerve
retracted mylohyoid
superficial
deep
parts of submaxillary gland
Wharton's duct
hypoglossal nerve
hyoglossus

PLATE 4

Approaches and Procedures for the Malar, the Maxillary and the Nasal Bones

Depressed fractures of the *malar bone* and comminuted and depressed fractures of the *nasal bones* are of common occurrence The displacements in such cases are usually reduced by leverage When stability is not secured after reduction, wire traction from the bone to an external splint will be necessary

Exposure of the malar and the nasal bones is not often required, but this is not so in the case of the maxilla, which contains the antrum and may require resection for carcinoma arising from the epithelium lining its cavity

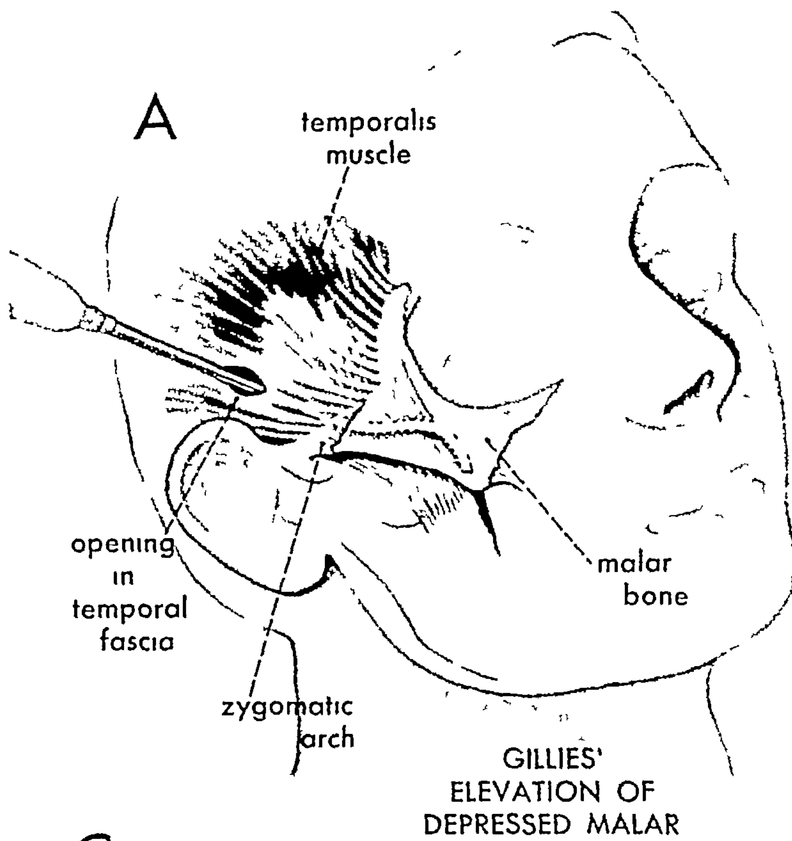
This plate is devoted to the common procedures on these bones, which are approached either directly or indirectly

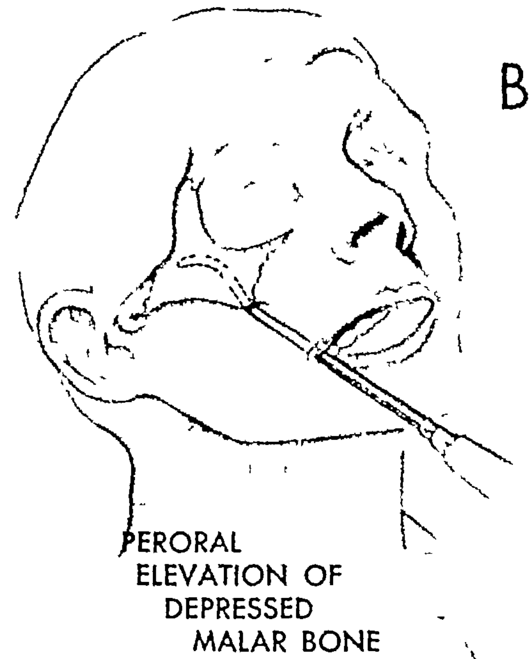
Attention should first be paid to Figures A, B and C which depict the indirect and the direct approaches to the malar bone, together with the procedures for reducing depressed fractures of them

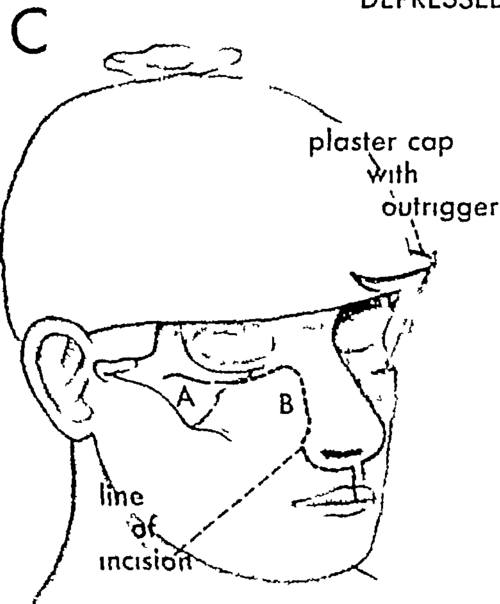
In A, an elevator has been passed through a small incision in the skin, through the layer of temporal fascia which is attached to the zygomatic arch, and then downward between the temporalis tendon and the zygomatic arch to rest on the deep surface of the malar bone The depressed bone can then be elevated readily, as described by Gillies Some workers prefer to introduce the elevator through the buccal mucosa and to carry out the elevation as depicted in B When stability of reduction is not obtained, the orbital ridge can be exposed by a short incision a, shown in Figure C Skeletal traction to an outrigger can be employed to maintain the bone in the corrected position

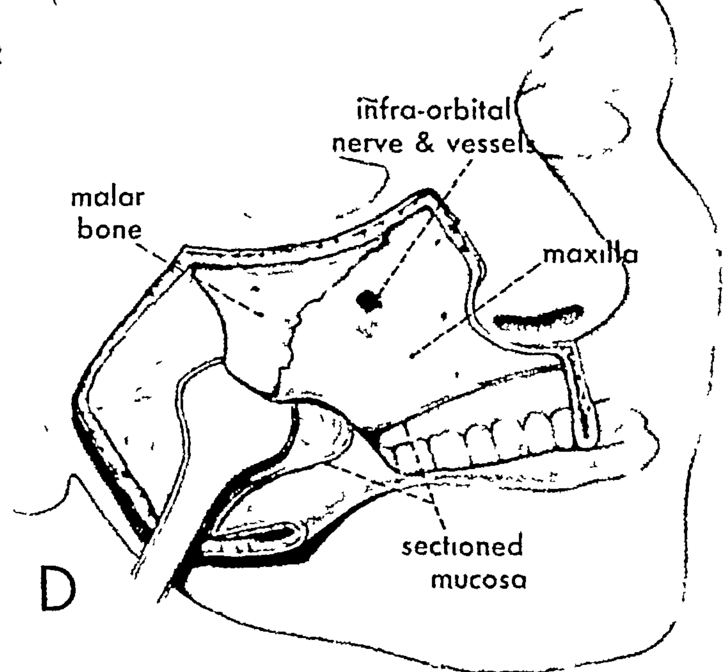
Figure C also shows the line of incision (a-b) for exposure of the *maxilla* The upper lip is sectioned in the midline, the incision continues round the nose and then along the inferior orbital ridge The mucous membrane at its gingival reflection is sectioned backward as required This gives an exposure of the whole extent of the superficial surface of the bone

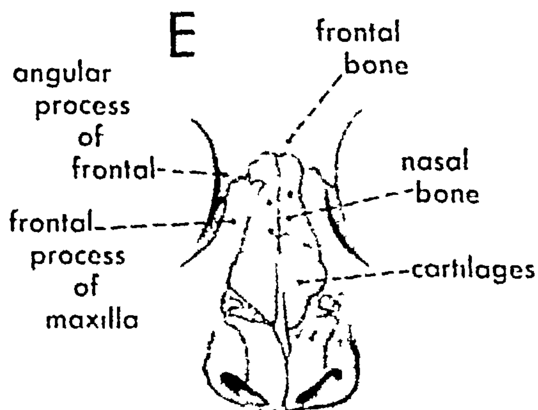
Figure E details the anatomic structure of the nose and shows the nasal bones and cartilages Depressed fractures are replaced by the introduction of forceps, covered by rubber tubing, into each nostril Maintenance with an external splint of molded lead or plastic usually suffices, but a wire loop tied over the splint is sometimes required

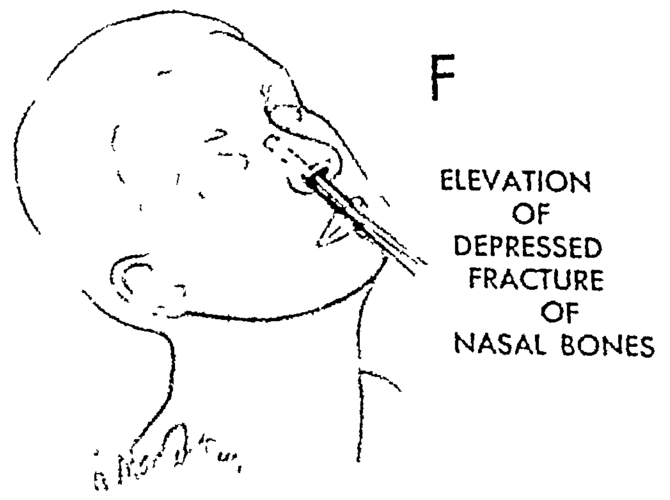

A
temporalis muscle
opening in temporal fascia
zygomatic arch
malar bone
GILLIES' ELEVATION OF DEPRESSED MALAR


B
PERORAL ELEVATION OF DEPRESSED MALAR BONE


C
plaster cap with outrigger
A
B
line of incision


infra-orbital nerve & vessels
malar bone
maxilla
sectioned mucosa
D


E
frontal bone
angular process of frontal
nasal bone
frontal process of maxilla
cartilages


F
ELEVATION OF DEPRESSED FRACTURE OF NASAL BONES

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3 TO 9

THE UPPER EXTREMITY

3

THE CLAVICLE AND ITS ARTICULATIONS

The *clavicle*, together with the articulations at its sternal and acromial extremities, is superficially placed throughout its length and affords an osseous protection to the major vessels and nerves so closely related to its deep surface It is readily accessible for surgical procedures, but the surgeon must always bear in mind the large venous channels related to the posterior aspects of the body of the clavicle and the sternoclavicular joint, which may be injured or torn at operation

Operative procedures on the *clavicle* are sometimes performed for fresh fractures to secure reduction and longitudinal wire fixation, as suggested by Murray Malunited and ununited fractures may necessitate exposure to correct bony deformity or to secure union by freshening the bone ends and applying a bone graft Section or removal of varying portions of the clavicle may be indicated for the exposure of aneurysms of the underlying major vessels or for the resection of the part affected by chronic osteomyelitis or neoplasm

The incidence of dislocations is much less in the *sternoclavicular* as compared with the acromioclavicular joint Acute dislocations of the sternal end are being subjected to primary operative repair in increasing numbers This is especially true of posterior displacements, in which pressure on major vessels, trachea and esophagus may necessitate immediate operative reduction for the relief of symptoms due to such pressure Resection of the inner end of the clavicle is advocated for chronic dislocations and for the relief of traumatic and degenerative arthritis of this joint

Mechanical derangements of the *acromioclavicular* joint constitute the most frequent disorders of the clavicular mechanism. They result from the accidents associated with athletics, travel and hazardous occupations Exposure of the joint and the coracoclavicular ligaments is indicated in certain dislocations in both the acute and the chronic stages Traumatic arthritis may follow subluxations, derangements of the intra-articular meniscus or fractures of the outer end of the clavicle These conditions, together with degenerative arthritis, can be relieved by excision of the outer end of the clavicle as advocated by Gurd and Mumford

PLATE 5

Anatomy of the Sternoclavicular Joint

This articulation provides the shoulder girdle with a pivot on the trunk and is interesting because an intra-articular meniscus bisects its cavity The integrity of this joint depends on the capsular and the rhomboid ligaments which are of sufficient strength to minimize the frequency of dislocations

The important surgical relations lie posteriorly, and this series of drawings emphasizes the extensive venous network, as well as the main vessels, of the thoracic inlet which must be considered in posterior dislocations and in operations involving the posterior capsular area The drawings progressively build up the structures from the left side to the right side

In a, the posterior relations of the joint to the main vessels, the pleural dome, the trachea and the esophagus are illustrated Any of these can be lacerated or compressed by the retrosternal displacement of the clavicle On the right side, Nature's protective buffer, formed by the sternothyroid muscles, is added These are closely applied to the posterior aspect of the capsule and are the protective mechanism of the great vessels in this area

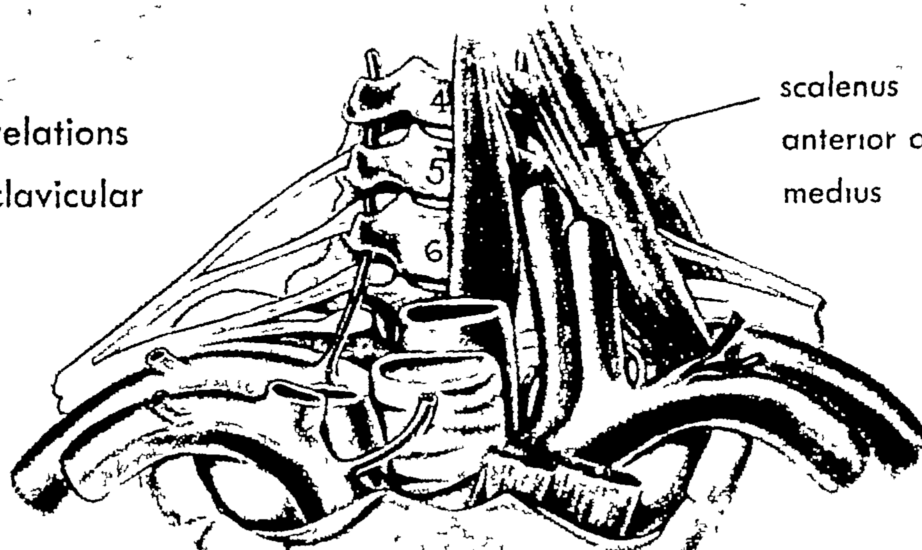
These muscles are depicted more completely in b, in which the posterior capsule and then the intra-articular meniscus and the rhomboid ligament are shown

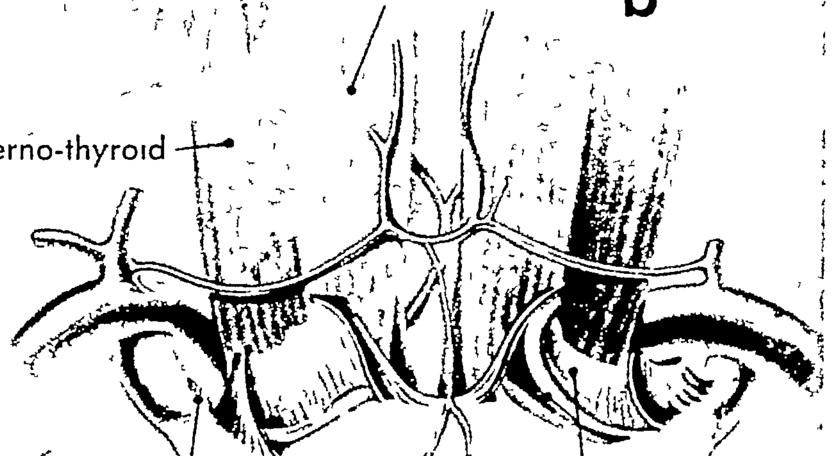
In c, the clavicles are placed *in situ*, and on the left a coronal section of the joint is illustrated It will be seen that the clavicle articulates with the intra-articular meniscus covering the sternal facet and extending on to the first costal cartilage The anterior sternoclavicular and interclavicular ligaments are present on the right side

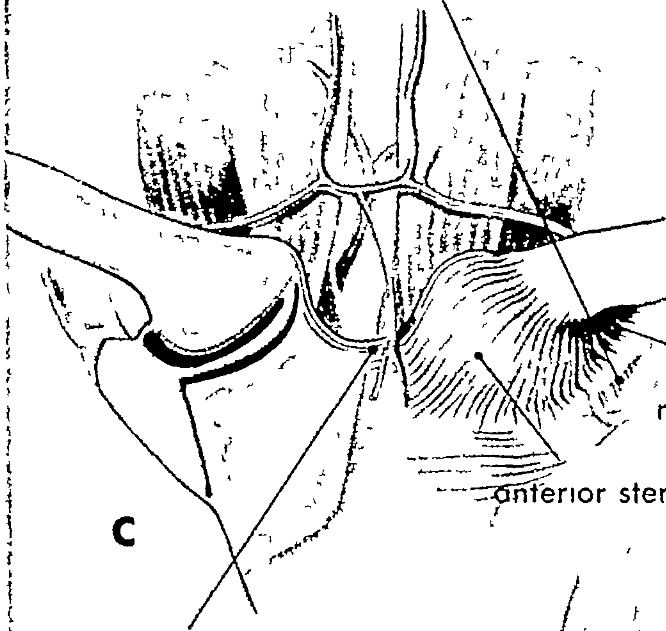
In d, the two insertions of sternocleidomastoid are shown in relation to the joint. The sternal head passes over the supermedial area of the anterior capsule, to which it is somewhat adherent The subclavius muscle arising on the first rib is viewed passing laterally to insert on the inferior aspect of the clavicle This important muscle acts as the buffer for the great vessels and nerves passing between the clavicle and the first rib to the upper limb It limits the sudden upward movement of the clavicle On the right side, the sternal and the clavicular heads of the pectoralis major are superimposed to complete the depiction of the anterior musculature

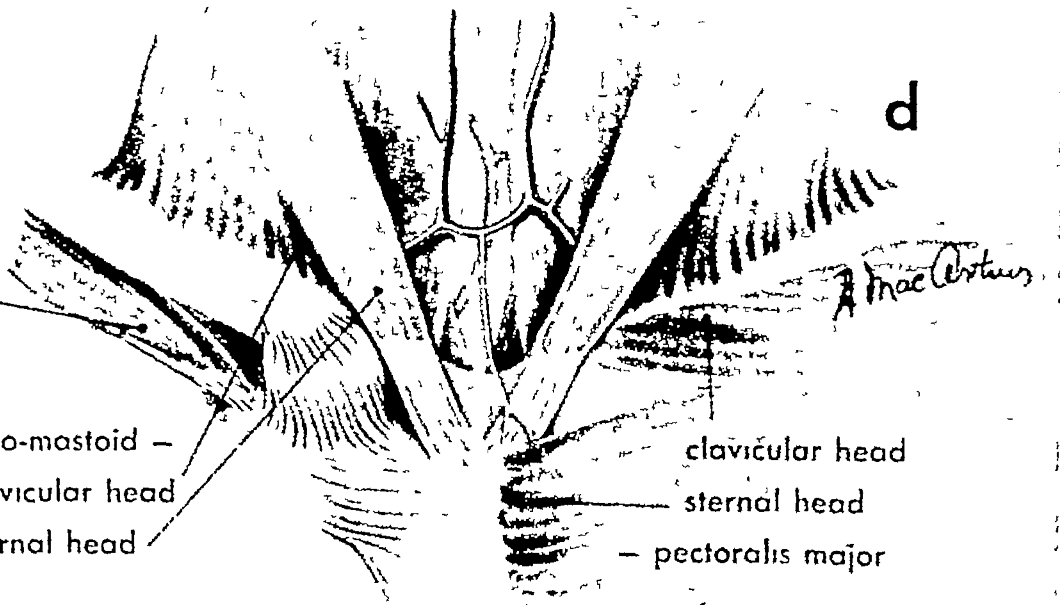
(Moseley, H F An Atlas of Shoulder Dislocations, North Chicago, Abbott)

posterior relations of sterno-clavicular joint









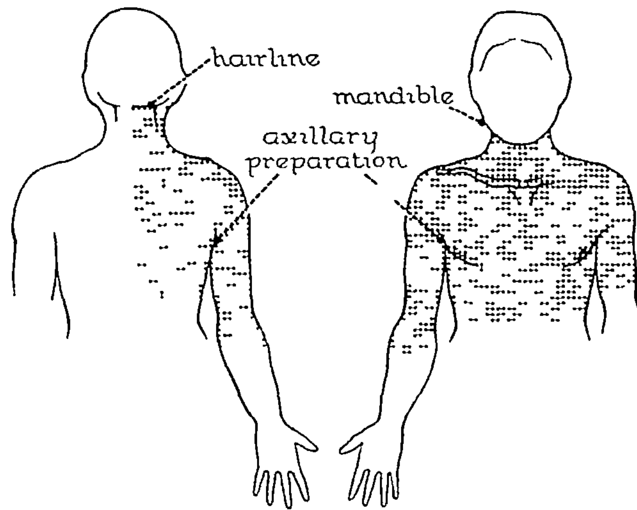


FIG 10 Area of skin preparation for operative procedures on the clavicle and the sternoclavicular joint

The skin preparation for operative procedures on the clavicle and the sternoclavicular joint must include, anteriorly, the surface of the neck, the chest, the shoulders and both arms, and, posteriorly, this aspect of the neck, the shoulder, the chest and the arm on the side involved All operative procedures on the upper extremity require careful shaving and meticulous preparation of the axilla When it is considered that manipulation of the upper limb will be necessary during the operation, the elbow, the wrist and the hand must be included, as in Figure 6

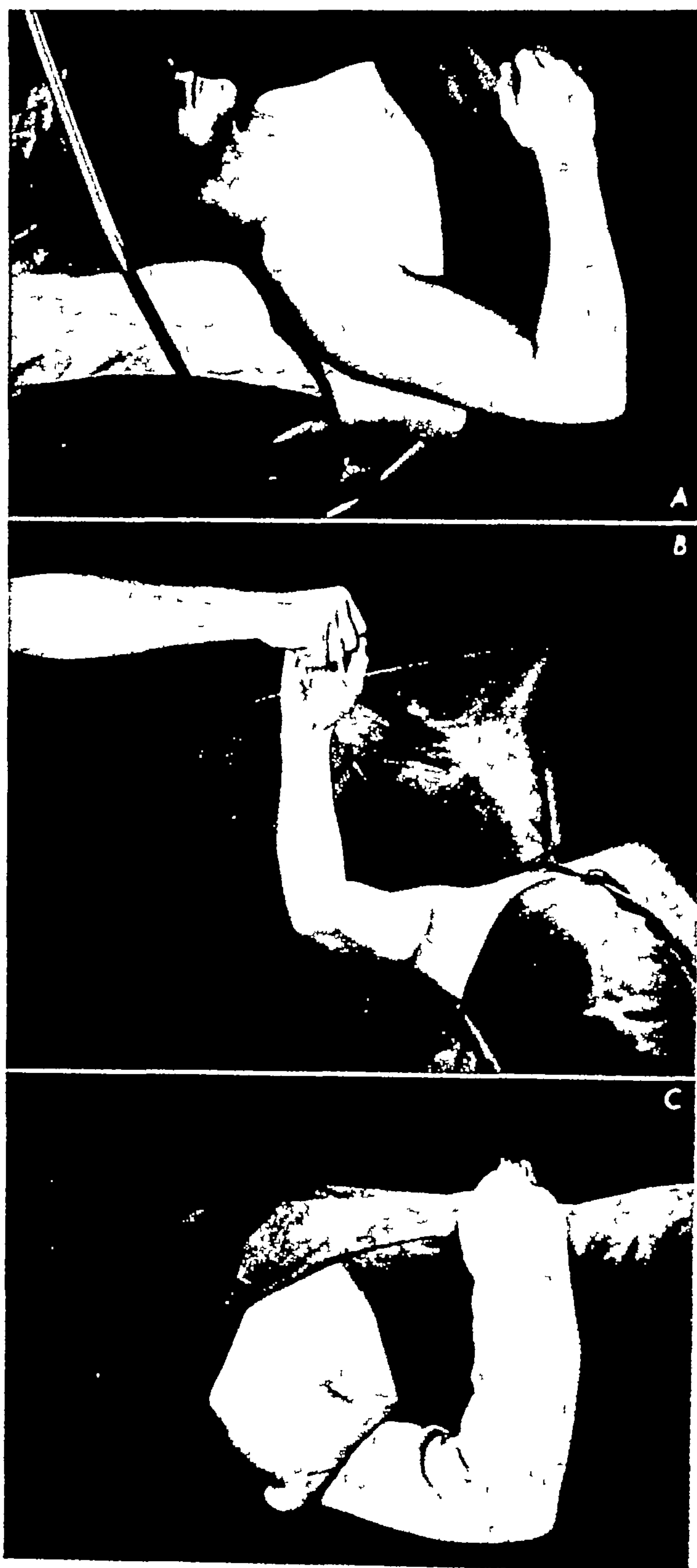


FIG 11 Posturing and draping for operative procedures on the clavicle and the sternoclavicular joint

(A) The patient is postured in the supine position A small sandbag may be placed under the scapula on the affected side An anesthetic screen is employed to close off the anesthetist and his apparatus from the operative field

(B) The foundation draping across the chest and the body and covering the screen is first applied During this step, the limb is held clear of the sterile towels by an orderly The hand is then received into a sterile towel, as detailed in Figure 15, and this is followed by the stockinet covering up to the axilla A 4-towel draping of the operative field is then arranged

(C) A further step is the application of the laparotomy sheet, through the hole in which the limb is passed The opening in the laparotomy sheet frames the field of operation

PLATE 6

Exposure of the Sternoclavicular Joint Illustrating the Types of Dislocation and Their Repair

The sternoclavicular joint is not frequently subjected to operative procedures Dislocations of this joint, whether partial or complete, are uncommon However, primary repair or secondary operations for chronic displacement, traumatic arthritis or degenerative arthritis from other causes may necessitate surgical exposure, followed by fascial repair or excision of the inner end of the clavicle This plate illustrates the exposure and fascial repair of an anterior dislocation, together with the typical displacements in the superior and the posterior types, which can be similarly treated

Plate 5 should be reviewed for the anatomic relationships before beginning the study of this operative series

Figure a shows the line of incision, which enables a flap of skin and subcutaneous tissue to be raised to expose the anterior capsule covered by the sternal head of the sternocleidomastoid The tendon of this muscle is dissected off the capsule and retracted medially The anterior capsule of the joint is reflected from the sternum, opening the joint and exposing the meniscus Figures b, c and d show the steps in the fascial repair advocated by Bankart The pectoralis major is reflected subperiosteally from the clavicle and the sternum adjacent to the joint In some cases a further suture is placed round the first costal cartilage in order to replace the torn rhomboid ligament

Figures e and f present the relationships in the superior and the posterior types of dislocation It will be remembered that the posterior dislocation may cause pressure on major vessels, the trachea and the esophagus, and thus reduction may be an emergency procedure Gentle reduction is essential in such cases In these types, as in the anterior type, primary operative reduction and repair is being accepted more and more as the treatment of choice

(Moseley, H F An Atlas of Shoulder Dislocations, North Chicago, Abbott)

anterior dislocation

a

line of incision

clavicle

manubrium

diagram of fascial repair

reflected pectoralis major

sternal head sterno-mastoid muscle

drill holes in manubrium

b

torn capsule

exposure of dislocated head

c

dislocation reduced

d

fascia in position and capsule sutured

e

superior type of dislocation

f

posterior type of dislocation

H MacArthur

PLATE 7

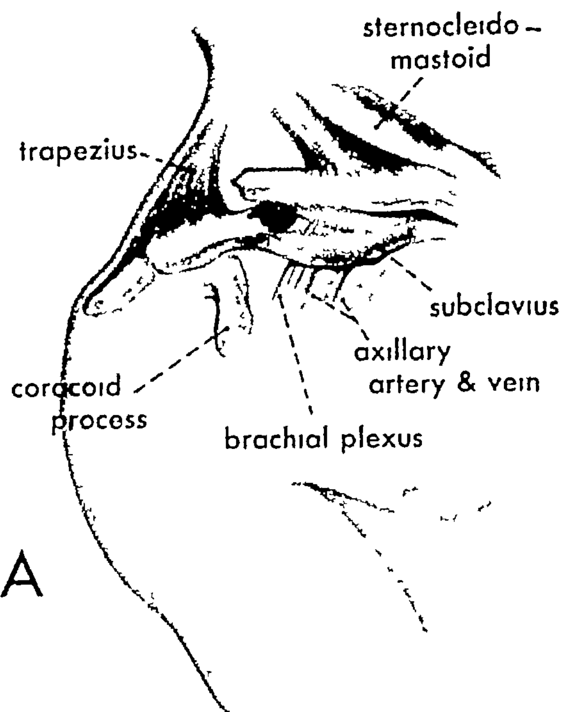
Exposure of the Clavicle and Murray's Operation for Longitudinal Wire Fixation of a Fracture

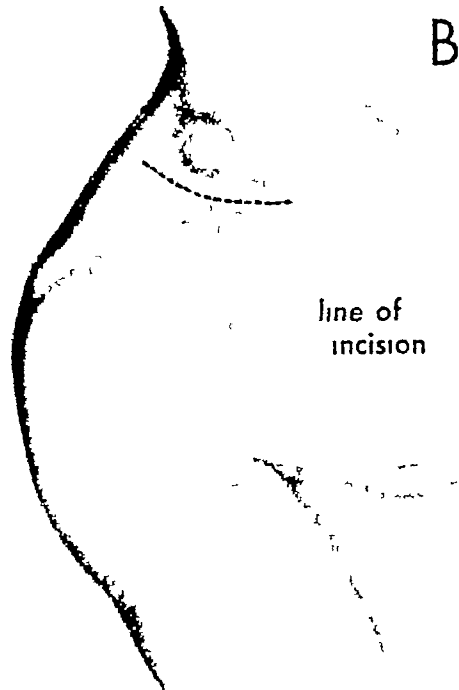
Fractures of the clavicle may be treated by longitudinal wire fixation, as described by Murray Most surgeons prefer operative exposure of the fracture site and insertion of the wire into the lateral fragment, followed by reduction of the fracture and insertion of the wire into the medial fragment, all under direct vision to avoid injury to the neighboring vessels, nerves and dome of the pleura

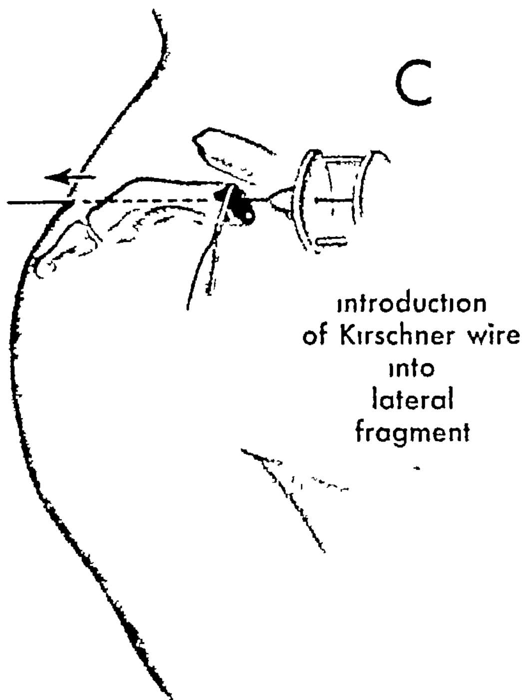
This plate illustrates Murray's procedure and should be further correlated with Plate 8, which details the anatomic relationships to be visualized during the operation

The characteristic displacements are shown in Figures A and B, together with the close proximity to the neurovascular bundle A useful line of incision which follows Langer's lines is indicated

After direct visualization of the fracture, the lateral fragment is drawn forward with a hook, and the wire is inserted along the medullary canal, out the posterolateral aspect of the clavicle and through the skin The fracture is then reduced and held in position by a clamp, while the Kirschner wire is drilled the requisite distance into the medial fragment The lateral end of the wire is sectioned so as to leave ¼ inch projecting from the bone under the skin The wire should be removed after roentgenograms show that union has occurred The time factor is 8 or more weeks


sternocleido-
mastoid
trapezius
subclavius
axillary
artery & vein
coracoid
process
brachial plexus
A


B
line of
incision


C
introduction
of Kirschner wire
into
lateral
fragment

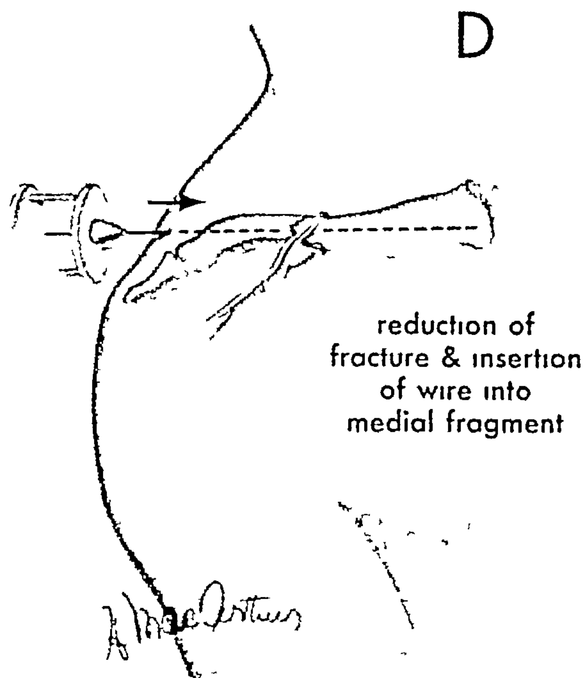

D
reduction of
fracture & insertion
of wire into
medial fragment

PLATE 8

The Anatomy of the Clavicle and the Acromioclavicular Joint

This plate illustrates the general relations of the clavicle to the first rib and the structures in the costoclavicular space which are liable to acute injury or gradual compression It also emphasizes the structural variability of the acromioclavicular joint

This joint possesses an intra-articular disk of variable form which gradually fragments during the years The four types illustrated in b are those described by Testut, but our investigations on anatomic and autopsy specimens have shown mostly menisci of the first type In older subjects, the disk is completely fibrillated

The articular facets on the clavicle and the acromion are also very variable in size and direction, as shown in c and d The most common type is the oblique overriding joint, which gives a loose mechanism compared with the vertical and the underriding types, which give a close-knit joint This latter group tends to show the most marked degenerative changes The author has not yet been able to correlate the clinical lesions with type joints or type menisci

The variability in the size of the articular facets is shown in superior projection in d The facets appear to extend more posteriorly with senescence

(Moseley, H F An Atlas of Shoulder Dislocations, North Chicago, Abbott)

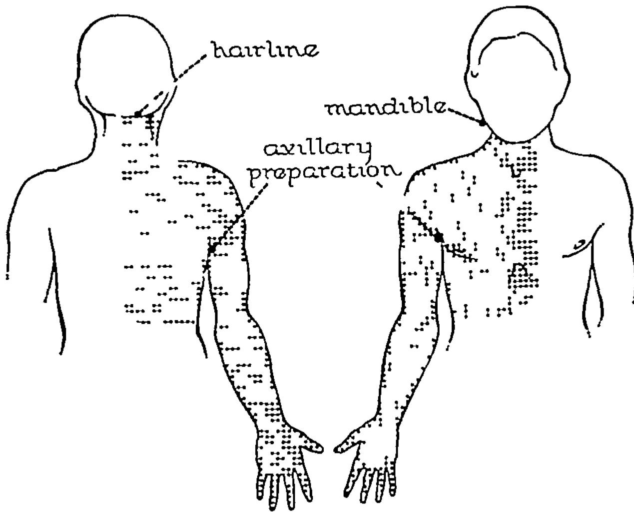


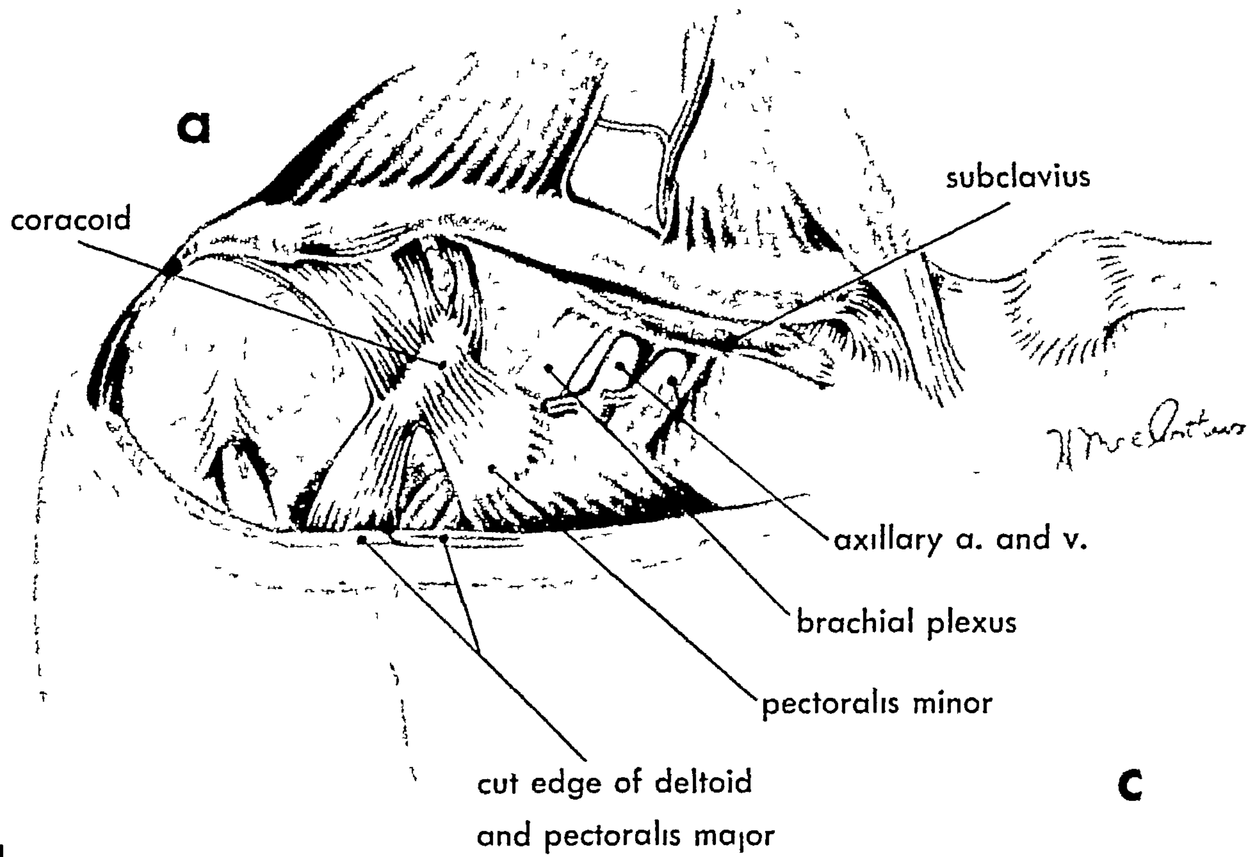
FIG 12 Area of skin preparation for operative procedures on the acromioclavicular joint

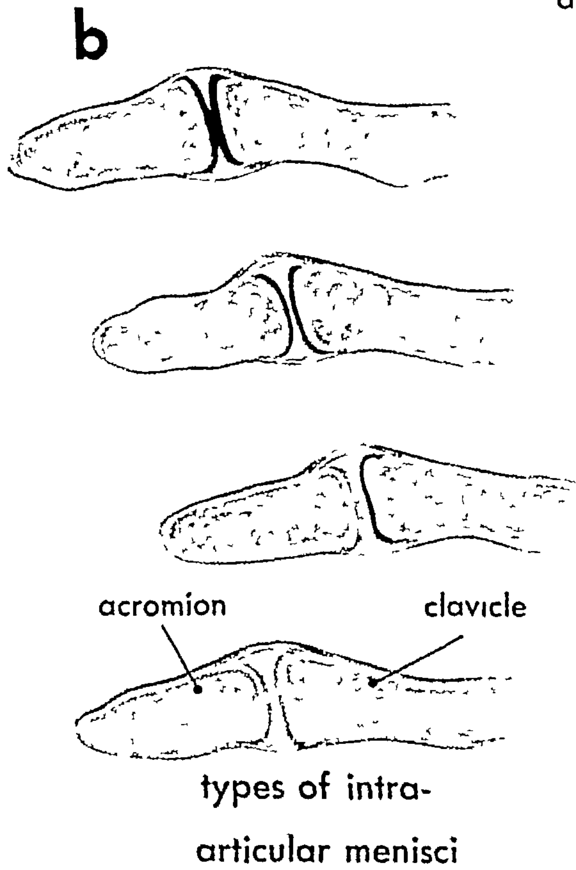
Operative procedures on the outer end of the clavicle and the acromioclavicular joint require skin preparation similar in extent to that for operations on the shoulder and the arm It is necessary to carry the preparation beyond the midline anteriorly and to the midline posteriorly for the side in question The whole limb should be prepared and special attention devoted to the axilla

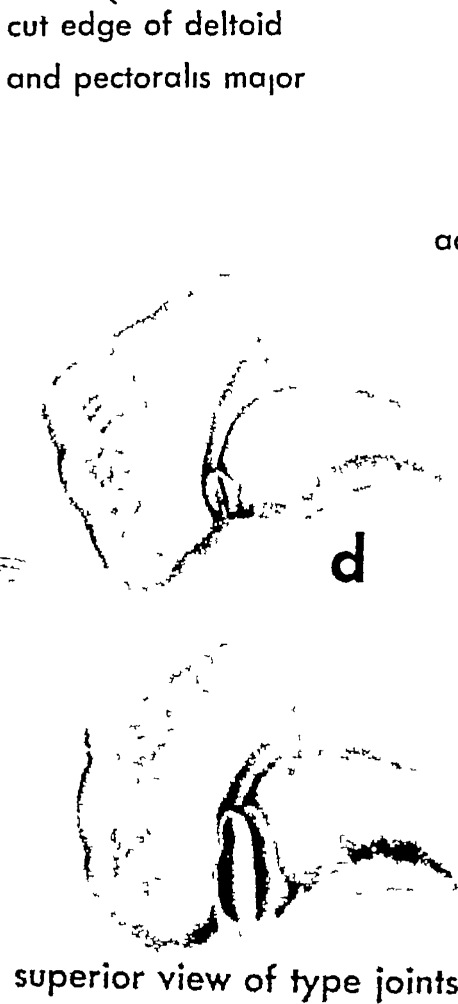


FIG 13 Posturing and draping for operative procedures on the acromioclavicular joint

The posturing and the draping for operations on the acromioclavicular joint differ in only one point from the posturing and the draping for operations on the clavicle and the sternoclavicular joint, as illustrated in Figure 11, i e , the posturing and the draping must frame the field more posteriorly and superiorly This is secured by using a larger sandbag under the scapula and by arranging the anesthetic screen to give more room at the superior aspect of the shoulder region In certain clinics the sitting position is used for this operative procedure to the great advantage of the surgeon







c

types of joints

acromion

clavicle

overriding

vertical

incongruous

underriding

PLATE 9

Exposure of the Acromioclavicular Joint and Excision of the Outer End of the Clavicle

Exposure of this joint may be required for primary or secondary operations after dislocation and for traumatic and degenerative arthritis The author has abandoned complicated fascial repairs and metallic fixation of this joint or the clavicle to the coracoid in favor of the simple procedure of excision of the outer end of the clavicle advocated by Gurd and Mumford The cut end of the clavicle is sutured to the coracoid to correct the upward displacement if the coracoclavicular ligaments have been avulsed but must not be arranged too tautly

The incision parallels that for the superior approach to the shoulder, but it is placed more medially, as shown in a

The aponeurotic fibers of the trapezius and the deltoid with the periosteum are incised as shown in b, and the outer end of the clavicle is cleared subperiosteally Using the circular saw, the clavicle is sectioned lateral to the posterior angle and the coracoclavicular ligaments Two drill holes are then placed, and a braided silk suture is passed in mattress fashion through soft tissues on the coracoid and through the clavicle The suture is tied loosely to hold the clavicle in its normal position This step is unnecessary when the outer end of the clavicle is removed for internal derangements or traumatic or degenerative arthritis of this joint The soft tissues are then approximated, giving an anatomic closure

(Moseley, H F An Atlas of Shoulder Dislocations, North Chicago, Abbott)

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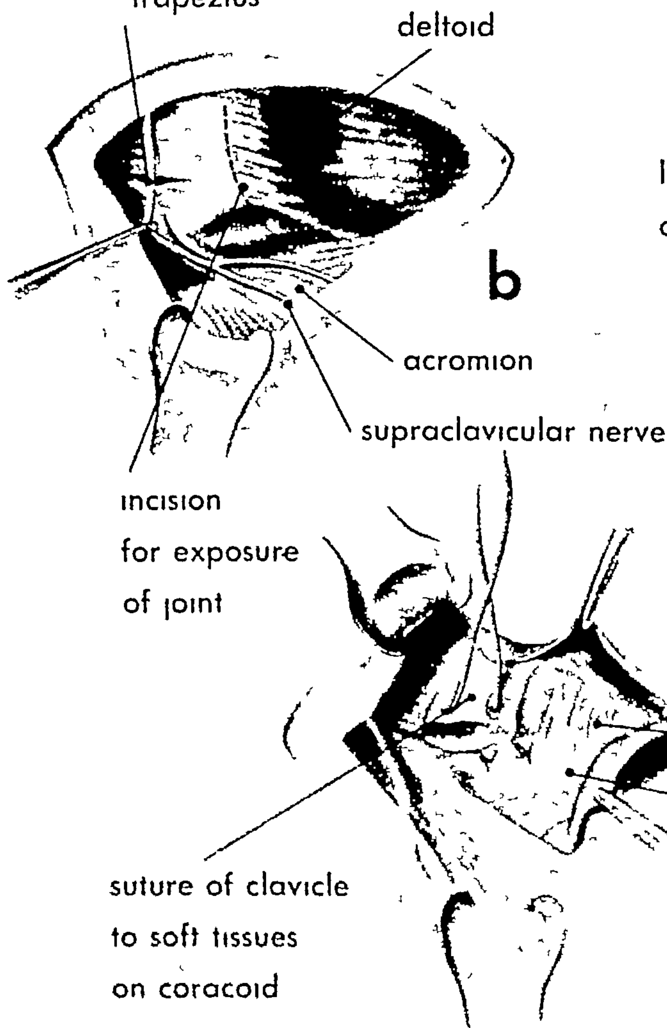
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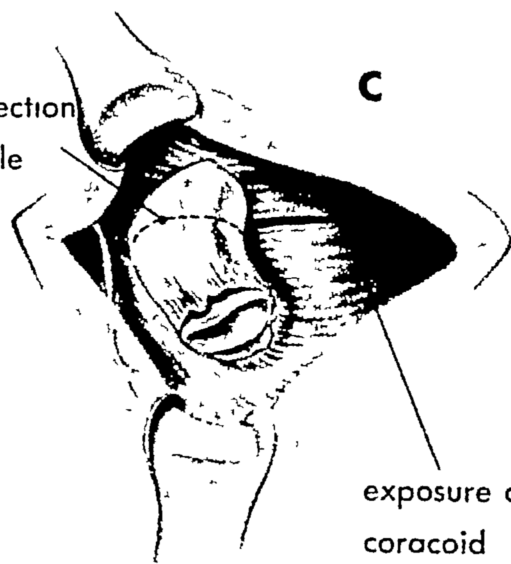
Film Surgical Approaches to the Sternoclavicular and Acromioclavicular Joints (surgical approaches, anatomy, and operation are shown for each joint by means of animation and dissection) (1952) (By LeRoy C Abbott, M D, Donald B Lucas, M D, Philip D Wilson, Jr, M D, and J B de C M Saunders, M B, San Francisco)

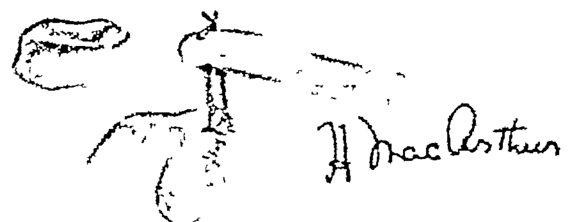
1¾ reels, 16 mm, sound color

Procurable from Central Office Film Library, Veterans Administration, Vermont Ave and H St, N W, Washington 25, D C


a
line of
incision


tear in
trapezius
deltoid
b
acromion
supraclavicular nerve
incision
for exposure
of joint
pectoralis minor
coracoid
suture of clavicle
to soft tissues
on coracoid
d


c
line of section
of clavicle
exposure of
coracoid



4

THE SHOULDER

The *shoulder* is the joint of the upper limb most frequently subjected to operative exposure Dislocations, ruptures of the cuff, calcified deposits, ruptures of the long tendon of the biceps, complicated fractures and many other orthopedic lesions necessitate exposure of the joint

The following exposures will be covered in this section·

Anterior or deltopectoral
Inferior or axillary
Superior or transacromial
Lateral or bursal
Posterior

The indulgence of the reader is asked, as the author's interest in shoulder lesions has resulted in greater detail in the illustrations and in the coverage of the subject in this section

The standard *anterior* approach is supplemented by that of Speed, in which the pectoralis major tendon is sectioned as well, and the use of this further step in the heavy-muscled athlete is mentioned The clavicular and even the acromial origin of the deltoid may be detached to increase the exposure suggested by Henry and Cubbins

Further, both the antero-inferior and the postero-inferior approaches are included These *inferior* approaches are of considerable scientific interest Future studies of dislocations, with and without axillary nerve paralysis, should further our knowledge of the exact relation of the capsular and the nerve lesions in such cases The author has employed the inferior approach in six cases of recurrent dislocation Wound infection has not been a complication to date, but steps were taken to arrange a careful preoperative preparation of the axilla and to afford the patient antibiotic protection This approach is not suitable for the obese patient and those with marked tendency to axillary perspiration or furunculosis Some female patients, when asked to consider the approach to be employed, have favored the axillary route because of the position of the scar It should be

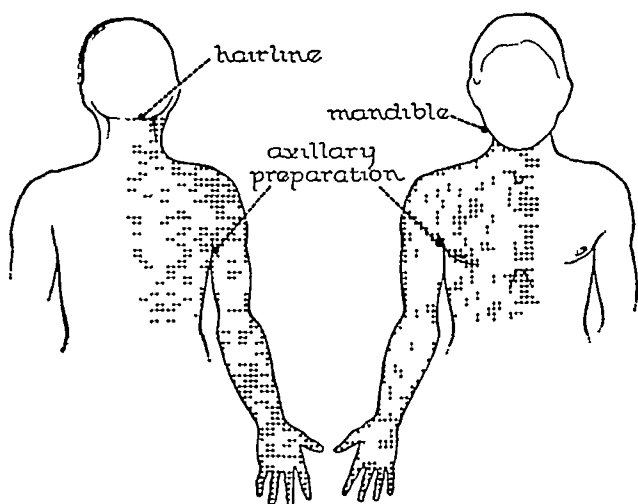


FIG 14 Area of skin preparation for operative procedures on the shoulder

The skin preparation is the same as for the operative procedures on the clavicle, the acromioclavicular joint and the arm For shoulder operations it is most essential to have the whole limb prepared so that it can be toweled and free for manipulation during the operation Special attention should be devoted to the hand, including cleansing of the nails and the cuticles

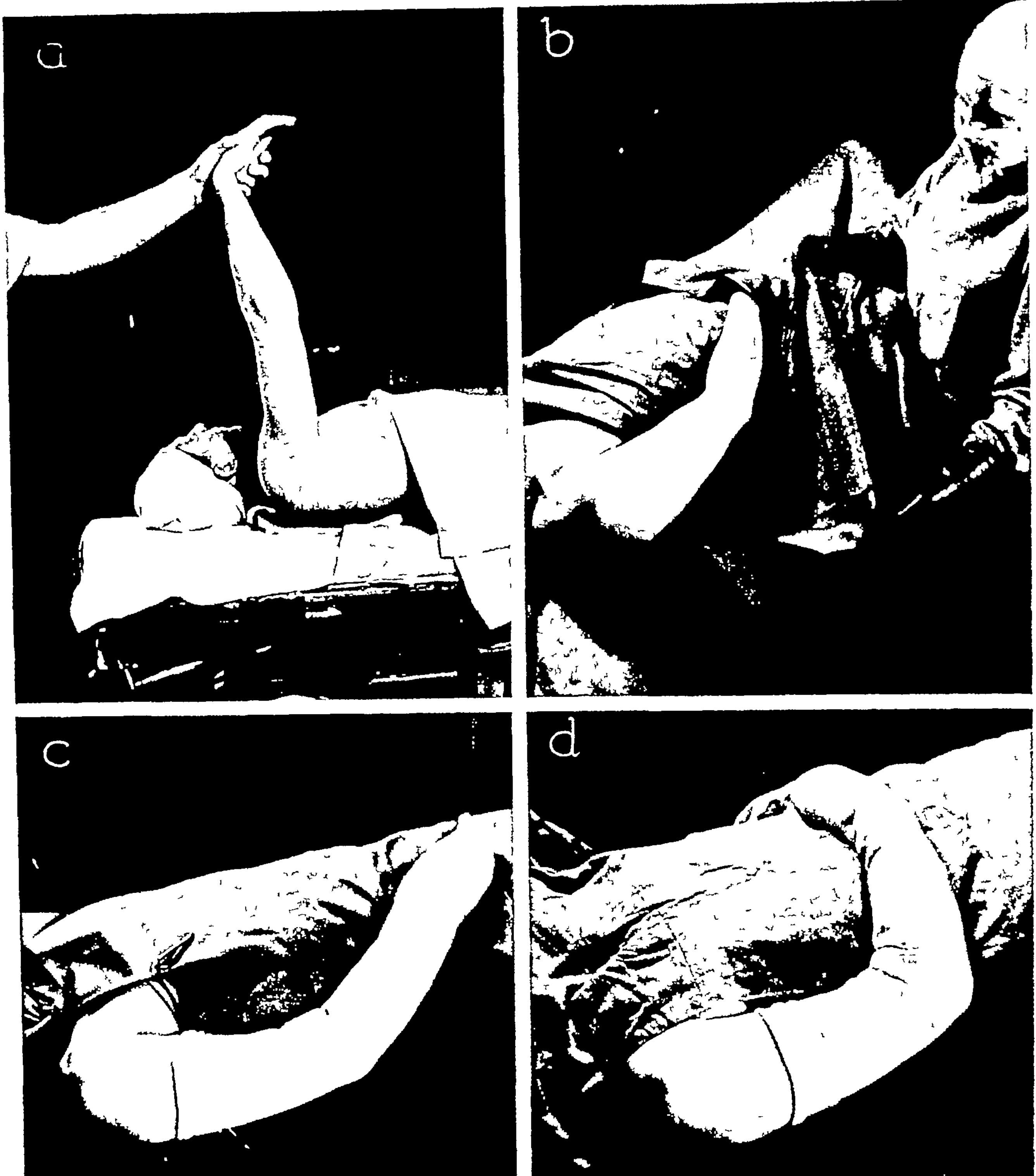


FIG 15 Posturing and draping for operative procedures on the shoulder (Moseley, H F: Shoulder Lesions ed 2, New York, Hoeber)

(a) The patient is postured in a supine position with a sandbag under the scapula on the affected side The orderly holds the limb at the wrist during the skin cleansing and the first step in the draping

(b) The foundation sheet has been placed and the hand and the forearm received into a sterile towel

(c) Stockinet is placed over the sterile towel and covers the upper limb to the axilla A 4-towel draping of the area of operation has been applied

(d) A laparotomy sheet is used as a coverall af er the limb has been passed through the opening

PLATE 11

Anterior Relations of the Glenohumeral Joint

The three drawings of Plate 10 illustrate the background on which the neurovascular bundle is placed Plate 11 shows these nervous and vascular structures in their relations to the glenohumeral joint and superimposes the muscles which intervene between these important tissues and the skin

In the first illustration, the neurovascular bundle has been retracted to expose the axillary nerve and the posterior circumflex vessels These course over the subscapularis, pass inferiorly across the axillary capsule in the quadrilateral space and gain posteriorly the deep surface of the deltoid The position of this nerve indicates why contusion or stretching, with resultant paralysis, occurs when the humeral head is suddenly displaced anteriorly and inferiorly The musculocutaneous nerve is noted lying on the surface of the bundle and sectioned at the point at which it would enter the deep surface of the coracobrachialis This nerve may be injured in dislocations, and it will be remembered that the musculocutaneous nerve supplies motor fibers to the coracobrachialis, the biceps and the brachialis anticus muscles

In the second and the third drawings, the two muscle planes represented by (1) the coracobrachialis, the biceps and the pectoralis minor and (2) the deltoid and the pectoralis major have been added The cephalic vein marks the division in this superficial sheet of muscle This deltopectoral interval is most easily identified just below the clavicle The complicated reversal of the position of insertion of the pectoral fibers in relation to their origin is also depicted

(Moseley, H F An Atlas of Shoulder Dislocations, North Chicago, Abbott)

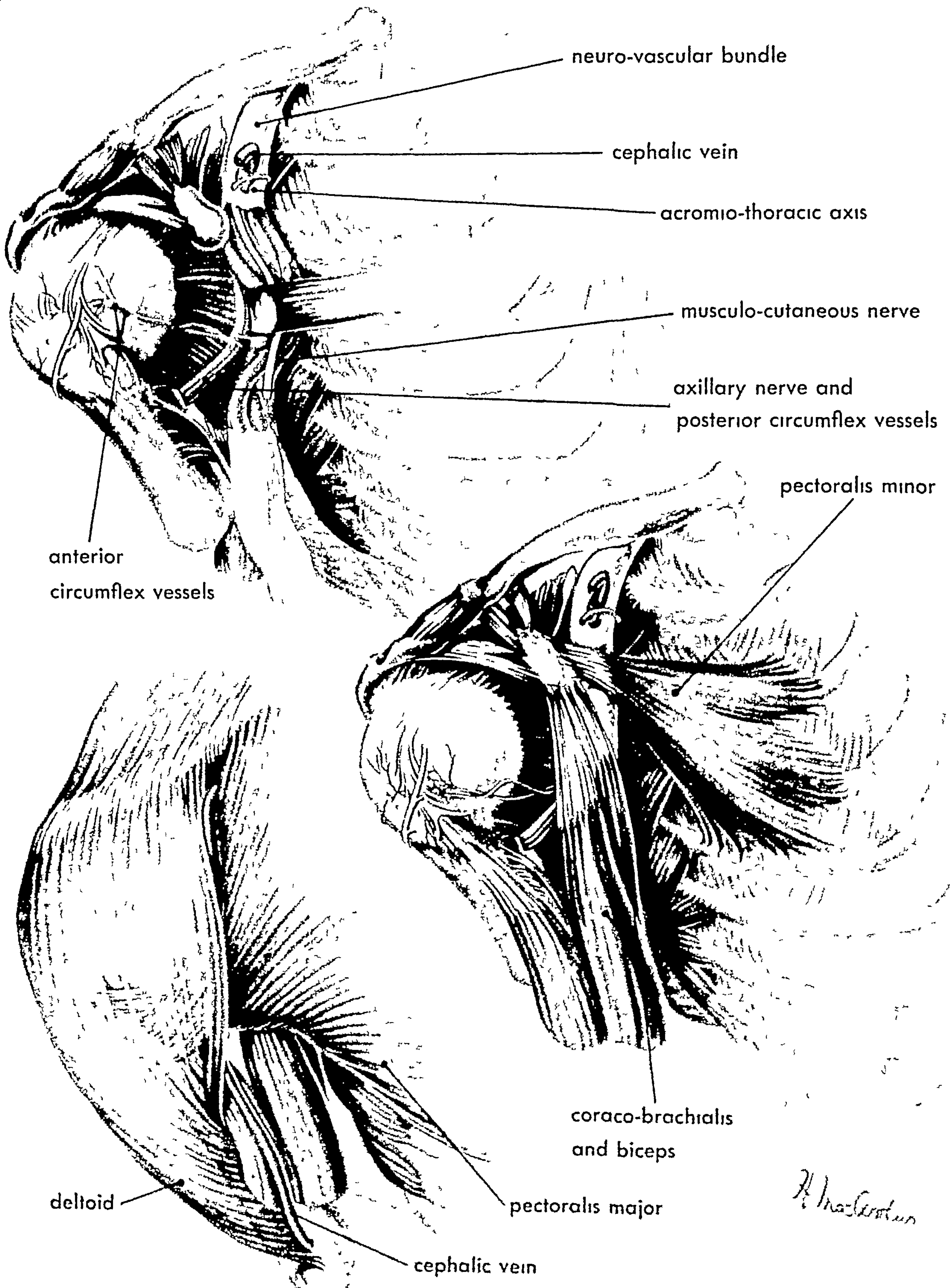

neuro-vascular bundle
cephalic vein
acromio-thoracic axis
musculo-cutaneous nerve
axillary nerve and
posterior circumflex vessels
pectoralis minor
anterior
circumflex vessels
coraco-brachialis
and biceps
deltoid
pectoralis major
cephalic vein

PLATE 12

The Anterior Approach

This plate illustrates the standard anterior approach to the shoulder joint through the deltopectoral interval

Position of the Patient The patient is postured in the supine position with a sandbag under the scapula on the affected side, as shown in A

Skin Incision A straight incision along the line of the deltopectoral interval is no longer employed, as it transgresses the lines of force (Langer's) and therefore tends to widen and become keloidal In its place a crescentic incision, with its convexity overlying the pectoralis major and the upper and the lower ends terminating on the deltoid, is employed with great improvement in the cosmetic result Through this incision of the skin and the subcutaneous tissues, the cephalic vein marking the muscular interspace is exposed It is the author's practice routinely to resect this vein over the length of the wound, as this diminishes subsequent troublesome hemorrhage during the operation

Deep Dissection The plane of cleavage of the muscular interspace is best found in the lower part of the wound, and it must be remembered that this interspace slopes posteriorly and laterally With the deltoid and the pectoralis major retracted, as shown in B, the upward expansion of the latter muscle attached to the outer lip of the bicipital groove will be seen and may with advantage be sectioned for a short distance near its insertion

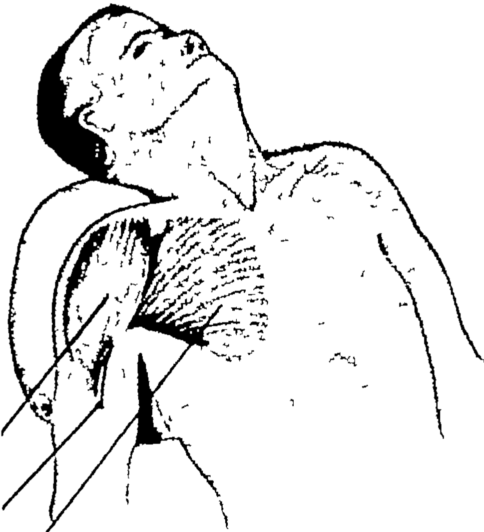
The coracoid process with the tendinous origins of the coracobrachialis and the short head of the biceps is seen in the upper and inner angle of the wound The line for its section is shown

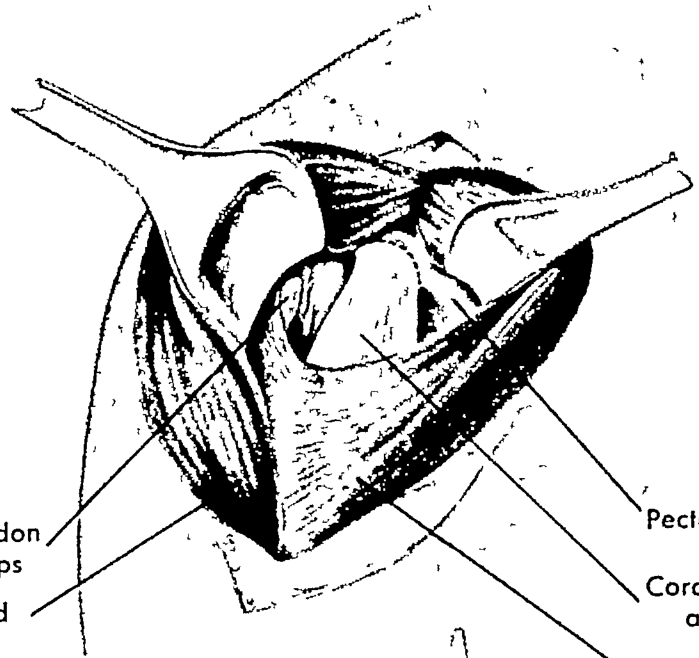
In C, the coracoid tip has been sectioned and, with its attached muscles, drawn downward and inward by a towel clip forceps The musculocutaneous nerve is illustrated in its correct position, but usually it is not seen at operation Its position must be remembered in order to prevent injury, with subsequent paralysis of the coracobrachialis, the biceps and the brachialis The line of arthrotomy is indicated at the musculotendinous junction of the subscapularis It should be remembered that medial to this line, and illustrated in Plate 11, runs the *axillary or circumflex nerve* which is the most important structure to avoid in this dissection It could be most easily injured in its lower portion, where the anterior circumflex vessels are found and serve the surgeon as a warning barrier to this nerve

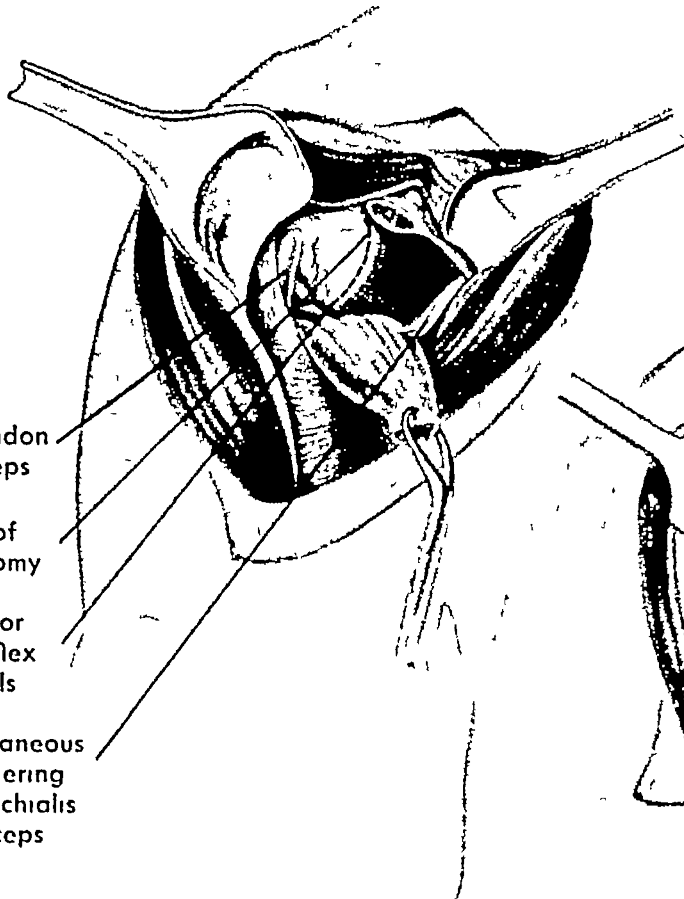
In D, the joint has been opened by section of the subscapularis tendon and capsule near the anterior bony rim The torn glenoid labrum is depicted as frequently found at operation

It will be seen that with this approach, the lower two thirds of the anterior glenoid rim is exposed In the thin subject, this is adequate for all repairs in this area In the heavy-muscled athlete, especially if he is of the short sthenic habitus, the glenoid rim is deeply placed and the exposure is often inadequate for the drilling of the bony rim, the placement of sutures and the capsular repair In such cases, section of the pectoralis major (as described in the following plate) is advisable

(Moseley, H F An evaluation of the exposures for anterior dislocations of the shoulder, Seminar International, Sharp and Dohme, **2** 11-17)


A
Deltoid
Cephalic vein
Pectoralis major


B
Long tendon of biceps
Deltoid
Pectoralis minor
Coracobrachiali and biceps
Pectoralis major


C
Long tendon of biceps
Line of arthrotomy
Anterior circumflex vessels
Musculocutaneous nerve entering coracobrachialis and biceps

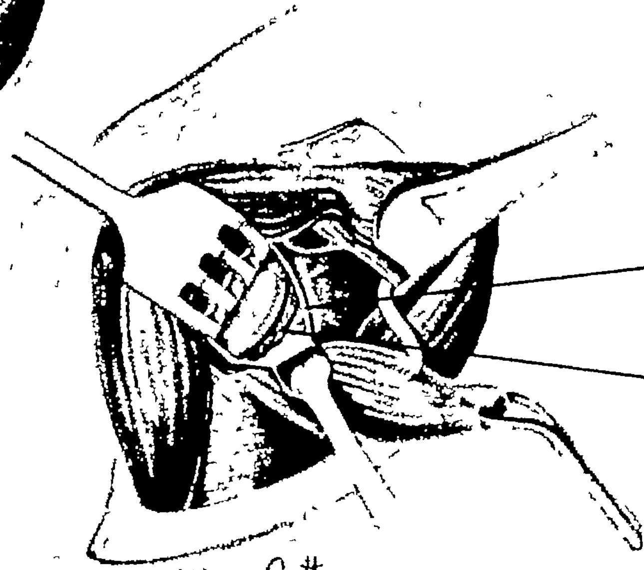

D
Sectioned subscapularis and capsule
Torn glenoid labrum
H MacArthur

PLATE 13

The Anterior Approach with Section of the Pectoralis Major Tendon

In those patients with a short arm and bulky deltoid muscle, the author has found the section of the pectoralis major tendon to be a valuable procedure in gaining adequate exposure This step was recommended by Dr Kellogg Speed

The early dissection is similar to that for the standard anterior exposure In B, the line for section of the pectoralis major is shown It is best to define first the lower border of this muscle, then pass an instrument or a finger deep to it for its full width and section it, leaving a stub on the bone which can be sutured readily on closure

In C, the important structures to be considered are illustrated The position of the axillary nerve just behind and medial to the musculotendinous junction of the subscapularis is clearly visible The relation of this nerve to the anterior circumflex vessels and the manner in which the surgeon can use these vessels to guard the nerve in the lower critical area of the repair can be understood The close relation of the neurovascular bundle to the operative field is observable

The closure of the exposure is readily made, the pectoralis major being repaired with mattress sutures The healing of this structure is usually such that at the end of the routine four weeks' immobilization in adduction, all movements can be restored gradually

(Moseley, H F An evaluation of the exposures for anterior dislocations of the shoulder, Seminar International, Sharp and Dohme, **2** 11-17)

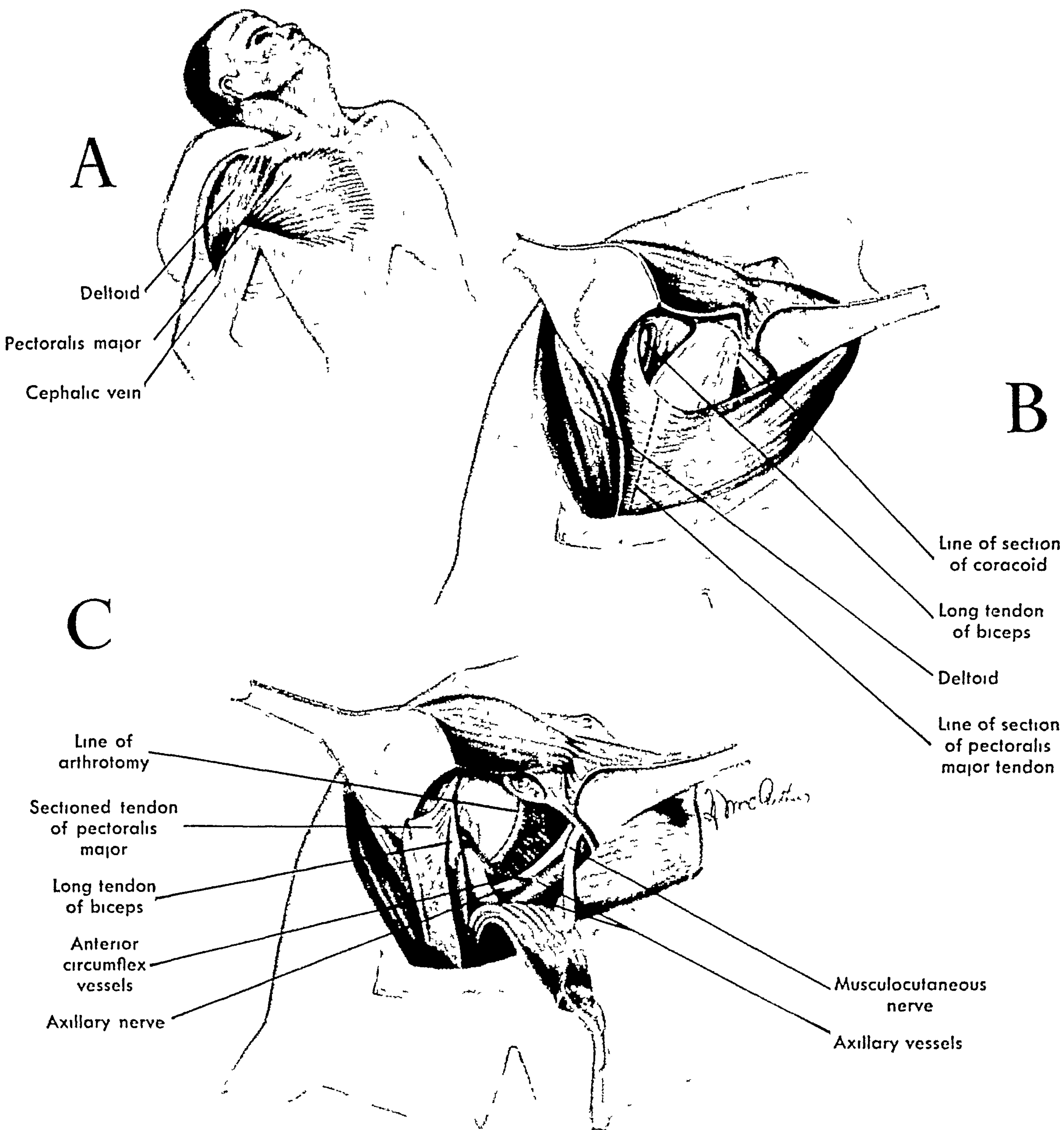

A
Deltoid
Pectoralis major
Cephalic vein
B
Line of section of coracoid
Long tendon of biceps
Deltoid
Line of section of pectoralis major tendon
C
Line of arthrotomy
Sectioned tendon of pectoralis major
Long tendon of biceps
Anterior circumflex vessels
Axillary nerve
Musculocutaneous nerve
Axillary vessels

PLATE 14

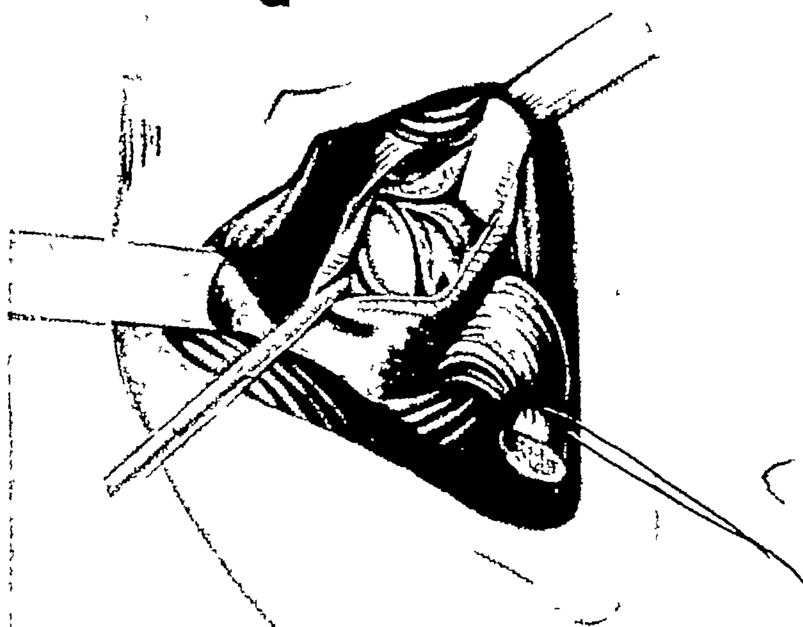
The Use of the Anterior Approach for the Bankart Repair of Recurrent Dislocations

The anterior exposure of the shoulder is used chiefly for the operative procedures to relieve recurrent dislocation of this joint Probably the principal reason delaying the universal adoption of the Bankart type of repair has been the difficulty of exposure of the antero-inferior portion of the glenoid rim Plates 12 and 13 illustrate this exposure without and with section of the pectoralis major tendon Plates 14 and 15 are included to assist the reader further by showing instruments and a prosthesis which facilitate the operation in the limited space available

The principle of this operation is to obliterate the antero-inferior pouch into which the head dislocates and to restore the anterior capsular mechanism by resuture of the capsule and the subscapularis tendon to freshened bone on the anterior glenoid rim The fibrocartilage of the glenoid rim is removed The two instruments shown in this plate greatly assist the surgeon in the placement of the required sutures The right-angled dental drill is employed to drill the bone, and a suture carrier is used to pass the sutures through the bone This plate should be correlated with Plate 15, in which a modification of this same operation is illustrated employing a Vitallium rim

The anterior approach can also be employed for the many other operations used for the relief of recurrent dislocations such as the Gallie and the Magnuson procedures with their many modifications The Nicola operation is best carried out through a deltoid split incision placed more laterally

(Moseley, H F An Atlas of Shoulder Dislocations, North Chicago, Abbott)

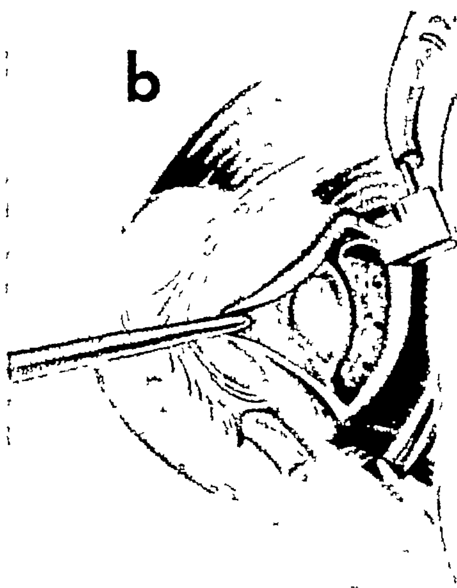


exposure
of glenoid rim
after reduction

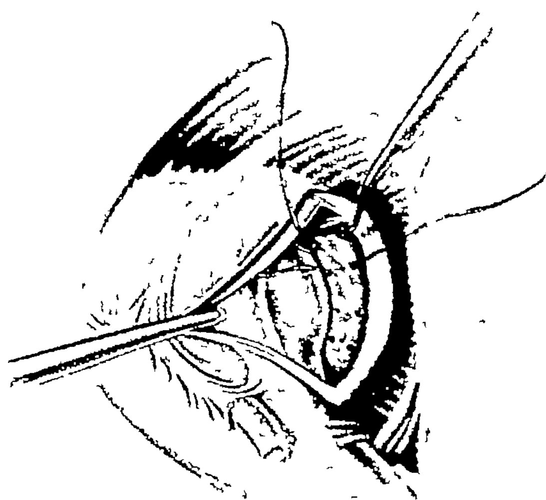




posttraumatic anatomy
—after closed reduction
—after open reduction



placement
of drill holes
in glenoid rim



placement
of sutures



suture of capsule
to glenoid rim

PLATE 15

The Use of the Anterior Approach and Application of a Vitallium Rim for Recurrent Dislocations

This plate depicts the steps in the application of the Vitallium rim which the author now uses routinely in his Bankart type of repair for recurrent dislocation of this joint

In A, the glenoid rim has been exposed after arthrotomy, as described in the legend for Plate 12 The torn labrum is removed and, using a blunt periosteal elevator, the neck of the scapula is cleared on its anterior and inferior aspects

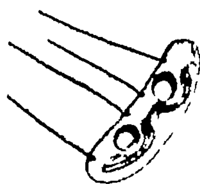
The bony glenoid rim is then freshened with a rongeur or an osteotome, as shown in B The Vitallium rim, with long sutures arranged through the holes on the prosthesis, as shown in D, is now placed on the neck of the scapula to see how it fits At this time the position for the upper drill hole is found, the rim is removed and the hole is drilled The rim is reinserted, and the first screw, ¾ inch in length, is placed to hold the rim *in situ* The correct position of the rim just medial to the joint cavity is secured, the second hole is drilled and the second screw is inserted Both screws are then tightened The four free ends of the suture are threaded, one by one, on a strong curved cutting needle and passed through the free edge of the sectioned subscapularis and capsule These sutures are tied in mattress fashion, the capsule being anchored to the raw bone of the glenoid rim The proximal portion of the subscapularis is sutured in overlapped fashion to the surface of the tendon with interrupted sutures

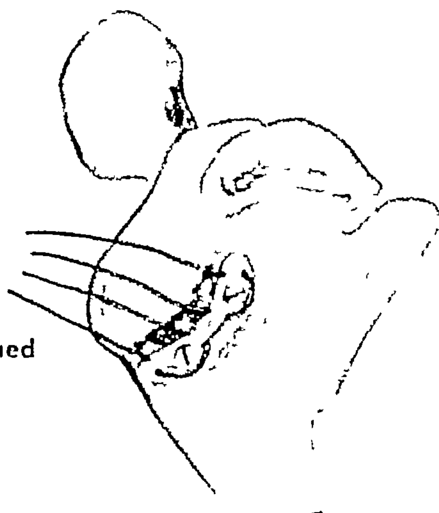
(Moseley, H F An evaluation of the exposures for anterior dislocations of the shoulder, Seminar International, Sharp and Dohme, **2** 11-17)


A
Axillary nerve
Articular cartilage of humerus
Sectioned subscapularis tendon and capsule
Antero-inferior glenoid rim with torn labrum


B
Rongeured bony rim


C
First drill hole for screw


D
Vitallium rim with sutures in situ


E
Rim applied

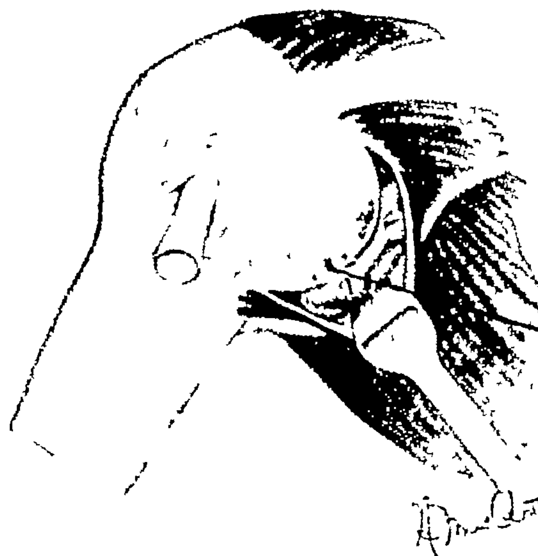

F
Suture of sectioned subscapularis tendon and capsule to raw bone

PLATE 16

The Antero-inferior or Axillary Approach

This was the approach developed by T T Thomas for his operation of plication of the antero-inferior capsule for recurrent dislocation of this joint He, however, made his incision in the length of the limb

Position of the Patient. The patient is postured in the supine position with a sandbag behind the scapula on the affected side The upper limb is draped so as to be freely mobile for manipulation It is abducted to a right angle, the elbow is flexed and the limb is supported at the wrist by an assistant

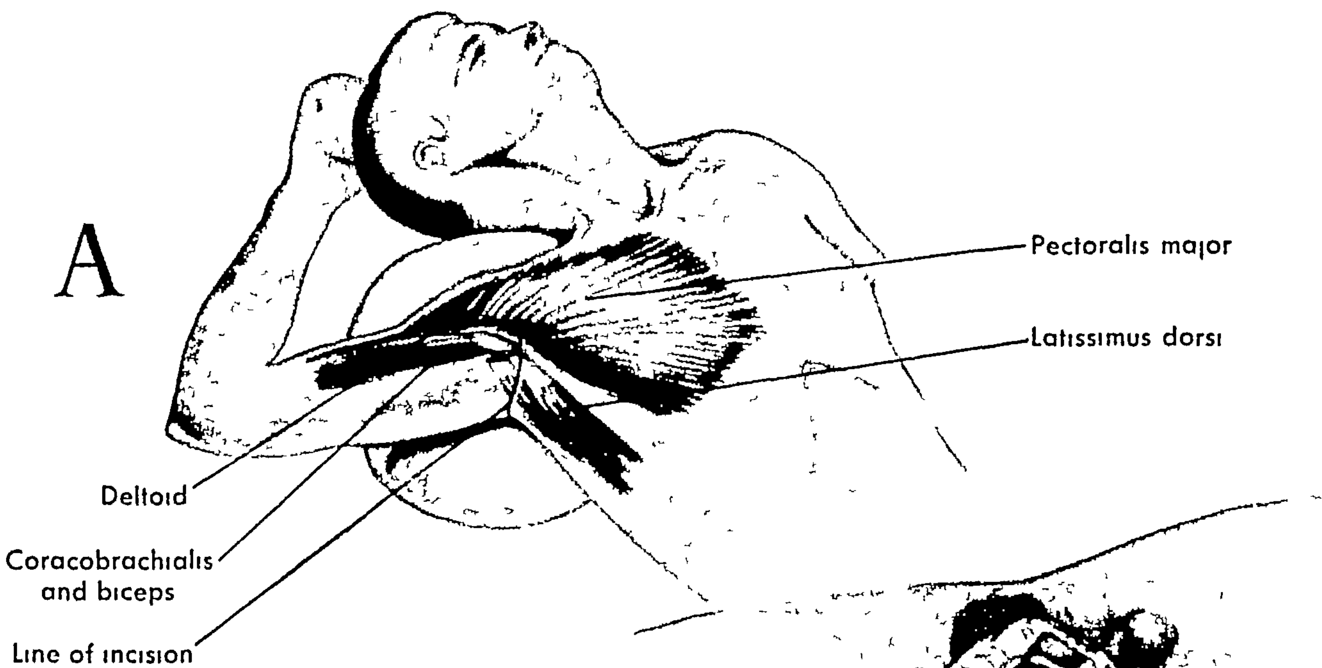
Skin Incision The skin incision may be in the length of the limb, running along the coracobrachialis, or transverse across the axilla as illustrated in A The structures to serve as landmarks are the lower border of the pectoralis major, the coracobrachialis and the prominence of latissimus dorsi and teres major

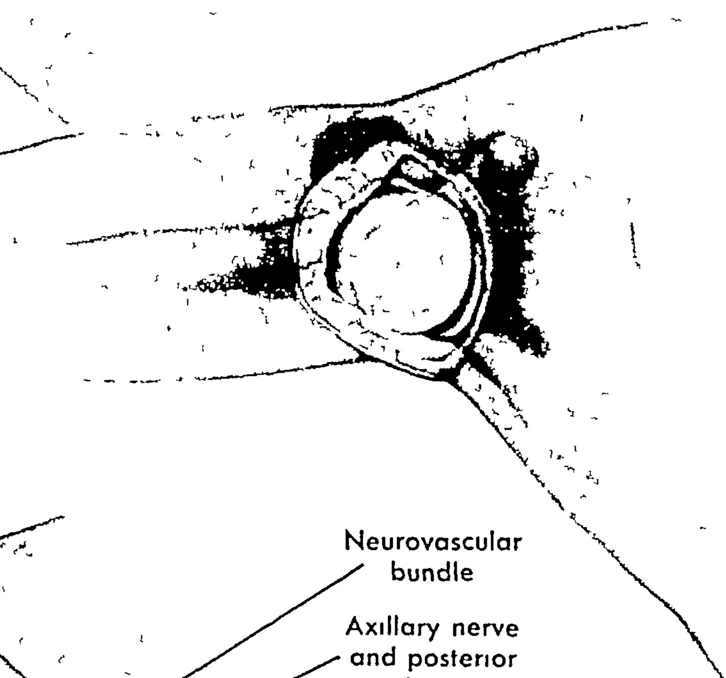
Deep Dissection The deep dissection should proceed as near as possible to the junction of the arm and the trunk In B, the bones are visualized through the wound Note especially the area of the antero-inferior glenoid rim

In C, all the important structures in the deep dissection are illustrated It will be noted that the exposure of the joint capsule is posterior and inferior to the main neurovascular bundle The axillary nerve and posterior circumflex vessels must be clearly seen as they pass over the lower border of the subscapularis muscle on to the inferior joint capsule near its humeral attachment The subscapular nerve and vessels will be observed coursing along the lower border of the subscapularis muscle The small area for the operative repair is found between the axillary and the subscapular nerves and vessels In the Bankart type of repair by means of this approach, the sutures must be tied while the arm is held in partial adduction

It can thus be concluded that this is an interesting but difficult exposure It gives a limited access to the area of operative repair and it requires an intimate knowledge of the surgical anatomy of this region

(Moseley, H F An evaluation of the exposures for anterior dislocations of the shoulder, Seminar International, Sharp and Dohme, **2** 11-17)


A
Pectoralis major
Latissimus dorsi
Deltoid
Coracobrachialis
and biceps
Line of incision


B

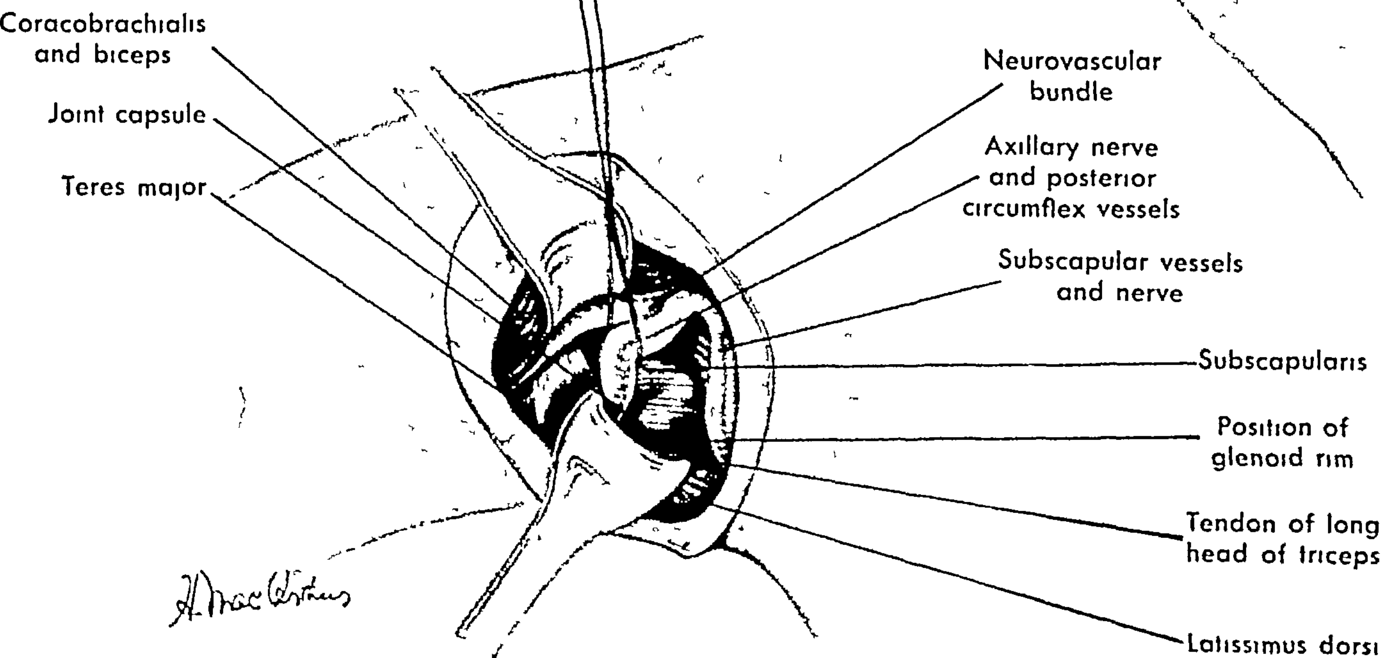

C
Coracobrachialis
and biceps
Joint capsule
Teres major
Neurovascular
bundle
Axillary nerve
and posterior
circumflex vessels
Subscapular vessels
and nerve
Subscapularis
Position of
glenoid rim
Tendon of long
head of triceps
Latissimus dorsi

Plate 17

The Postero-inferior Approach

The postero-inferior and the antero-inferior approaches may be regarded as different parts of a single exposure through the same axillary incision However, for the postero-inferior approach, the patient is postured in the semilateral position, being partly turned over to the opposite side and held there by a posteriorly placed pillow and sandbags The limb is draped so as to be sterile for manipulation in its full length and is held in the completely abducted position to cause the humeral head to bulge inferiorly, as shown in A

The *skin incision* is transverse across the axilla and is as near the base of the limb and the chest wall as possible The fatty subcutaneous tissue and the deep fascia are sectioned

Deep Dissection In B, the long tendon of the triceps is shown This is the chief landmark in the early part of the deep dissection Its anterior border should be carefully defined, and it should be cleared proximally to its scapular origin

In C, the important structures in this exposure are illustrated For clarity, the long tendon of the triceps is shown retracted backward, but it must be stated that this is rarely possible at operation, since it is so closely and tautly applied to the inferior capsule when the humeral head bulges inferiorly with the limb in full abduction

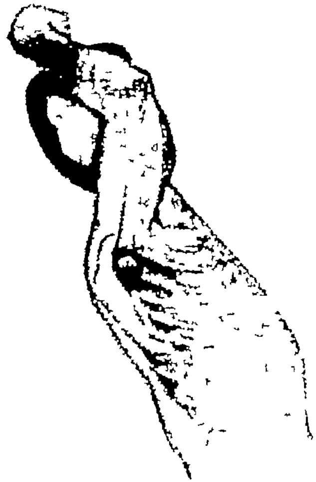
The teres major and the latissimus dorsi are retracted forward, exposing the fibers of the subscapularis passing to insert on the humerus

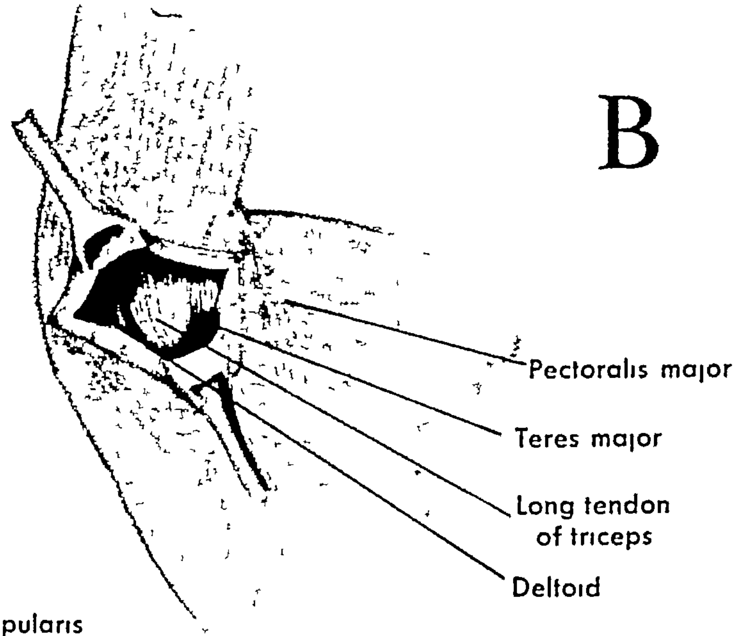
The axillary nerve and the posterior circumflex vessels are easily seen on the inferior capsule and are nearer the humeral than the scapular attachment of the capsule This position probably accounts for the infrequency of axillary nerve injury in antero-inferior dislocations in which the ligamentous tear is most frequently found at the scapular attachment

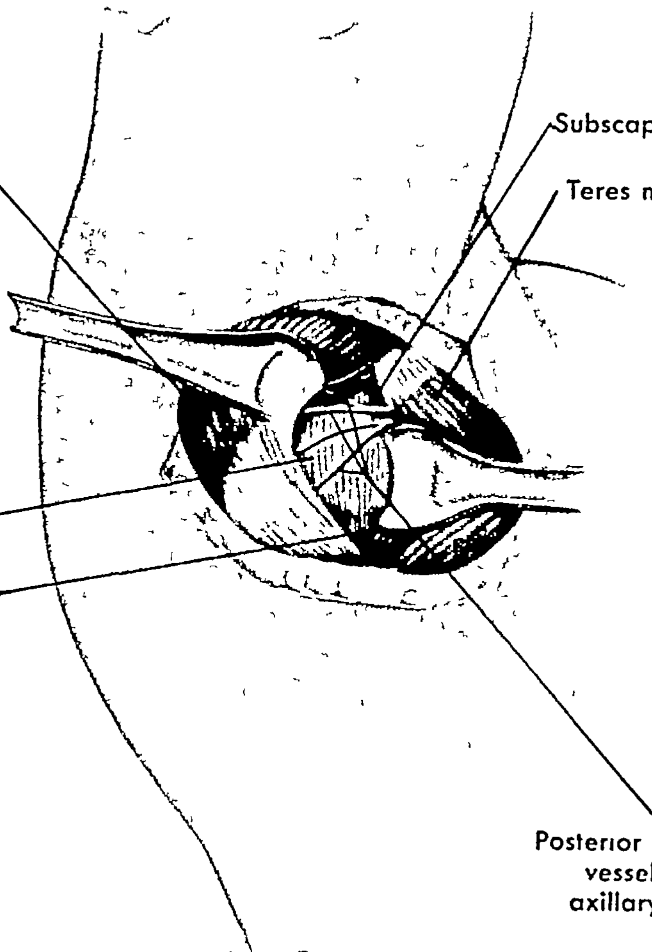
In D, the positions of the glenoid rim and the joint cavity are illustrated For diagrammatic purposes the joint spacing is increased by traction on the limb However, at operation the articular surface of the humeral head will be found to extend beyond the glenoid rim, to which it is closely applied

This approach gives an excellent exposure of the inferior joint capsule and glenoid rim, but it does not permit visualization of the anterior glenoid rim to any extent. It is especially valuable in the exposure of the axillary nerve in its relation to the joint capsule When used for the Bankart type of repair, the sutures repairing the capsule must be tied with the limb partially adducted The author's interest in this exposure was stimulated by a personal communication from Dr Sterling Bunnell

(Moseley, H F An evaluation of the exposures for anterior dislocations of the shoulder, Seminar International, Sharp and Dohme, **2** 11-17)


A


B
Pectoralis major
Teres major
Long tendon of triceps
Deltoid


Subscapularis
Long tendon of triceps
Teres major
Capsule
Position of glenoid rim
C
Posterior circumflex vessels and axillary nerve

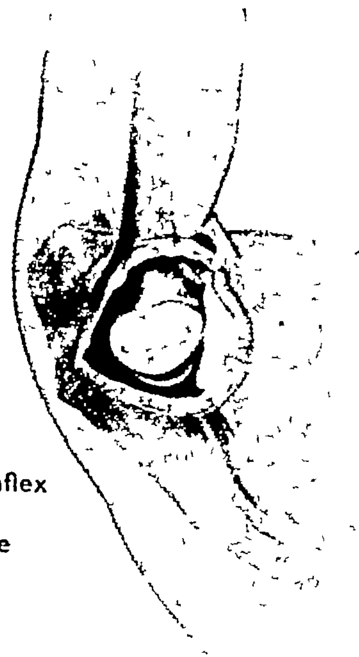

D
Localization of glenoid rim through incision

PLATE 18

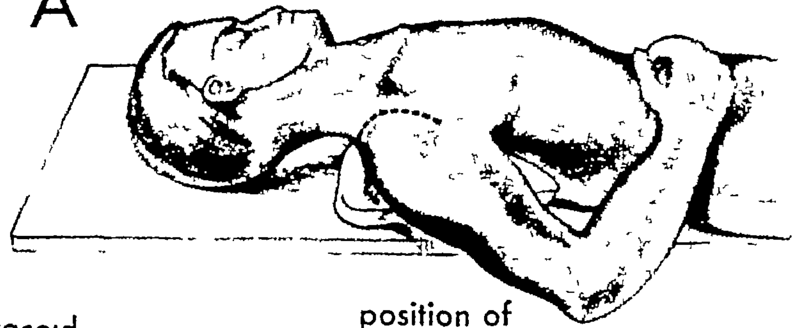
The Superior Approach with Exposure of an Avulsed Supraspinatus Facet

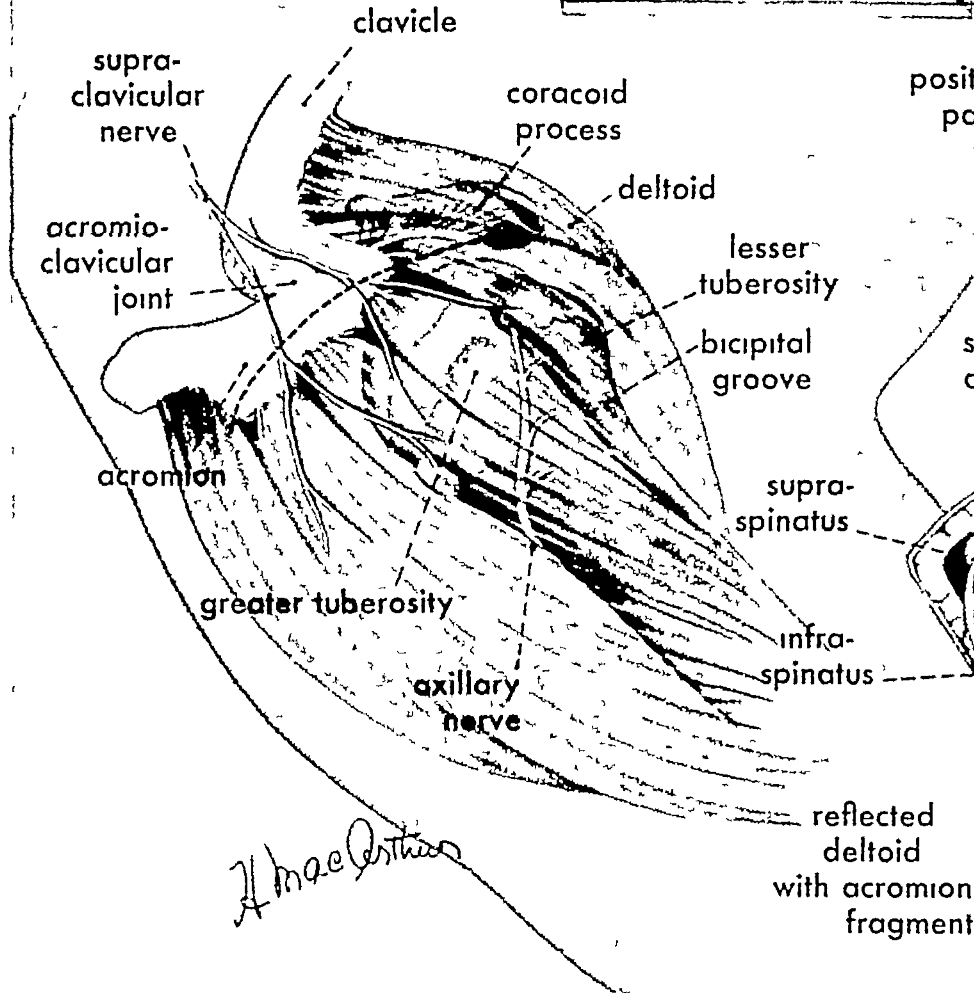
The superior approach affords the best exposure of the superior aspect of the cuff and area of the greater tuberosity, but it is a major procedure And the section of the acromion with resuture or removal of the distal fragment disrupts the normal coraco-acromial arch, and recovery of full function of the deltoid and full movements of the joint require a period of three or more months Recent ruptures of the cuff, with or without avulsion of fragments of the greater tuberosity, together with calcified deposits, can be treated satisfactorily through the lateral exposure (Plate 19) The superior approach should be reserved for the major procedures on this region of the shoulder joint

Figure A shows the patient in the supine position with a sandbag under the scapula It is best to have the proximal end of the sandbag flush with the superior surface of the shoulder region so as to afford the maximal operative field superiorly and posteriorly

The line of incision is indicated in A and again in B In some cases it is possible to preserve the acromial branches of the supraclavicular nerves The deltoid is split in the direction of its fibers from the prominent anterior tubercle of the acromion The acromion is sectioned from before backward just lateral to the acromioclavicular joint The deltoid is then retracted downward and backward, giving an excellent exposure of the superior aspect of the rotator cuff and bursa

In C, an avulsion of the supraspinatus facet is shown through the exposure afforded by the superior approach If the fragment is comminuted, it can be excised, or if it is of considerable size, it can be reduced and held by sutures through the bone The massive and neglected cuff tears can also be repaired through this approach


A
position of
patient & line of incision
for superior approach


B
clavicle
supra-
clavicular
nerve
coracoid
process
deltoid
acromio-
clavicular
joint
lesser
tuberosity
bicipital
groove
acromion
greater tuberosity
axillary
nerve
infra-
spinatus
reflected
deltoid
with acromion
fragment

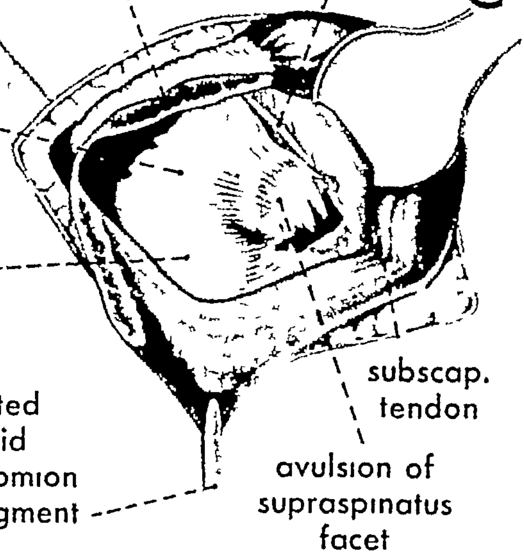

C
longitudinal
tear in
cuff
sectioned
acromion
supra-
spinatus
subscap.
tendon
avulsion of
supraspinatus
facet



FIG 16 General arrangements for the lateral approach exposing an acute calcified deposit (Moseley, H F Shoulder Lesions, ed 2, New York, Hoeber)

PLATE 19

Lateral or Bursal Exposure

The skin incision is a curved transverse incision running toward the lines so obvious on the front of the shoulder near the lower border of the pectoralis major tendon This heals with an excellent cosmetic result compared with the old vertical incision which was so subject to widening and keloid formation The skin flaps are undermined at the level of the deep fascia covering the deltoid

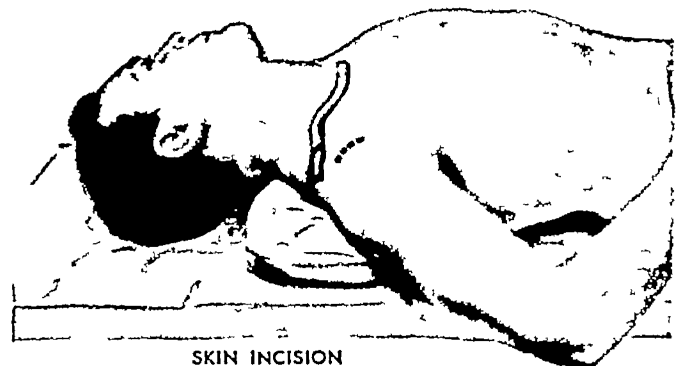
The deltoid is palpated for a fascicular groove, which is best found at the level of the prominent anterior tubercle of the acromion An avascular splitting to the roof of the bursa can then be secured and retraction arranged This deltoid splitting must not exceed 2½ inches, otherwise major branches of the axillary nerve will be damaged

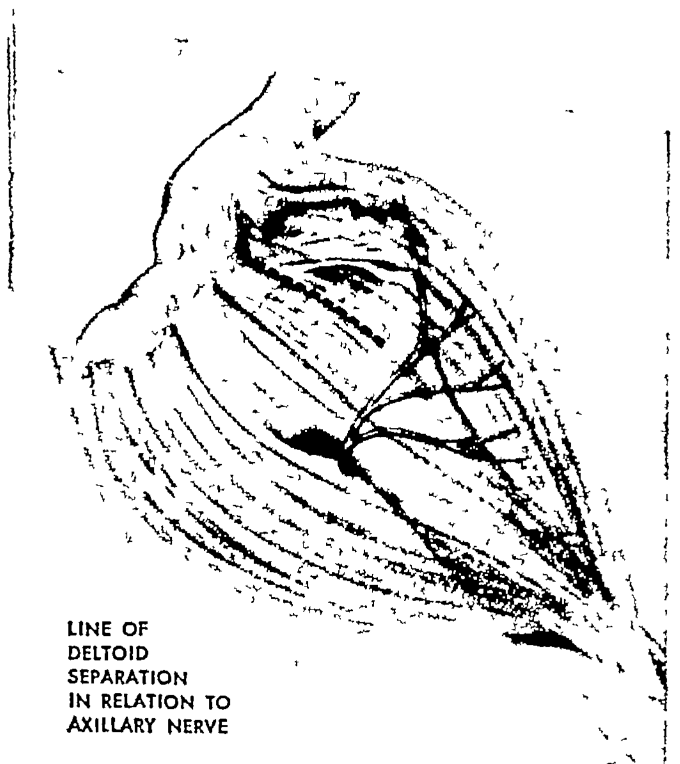
The coraco-acromial ligament can be seen in the anterosuperior angle of the wound Rotation of the limb permits a wide area of the bursa and the cuff to be visualized Localization of the components of the cuff is obtained by digitally palpating the bicipital groove Anteriorly will be the subscapularis, superiorly, the supraspinatus and the infraspinatus, posteriorly, the teres minor

The roof of the bursa must be removed for a study of the cuff and the greater tuberosity Arthrotomy can be performed by opening the joint along the intersection between the subscapularis and the supraspinatus tendons

(Moseley, H F Disorders of the shoulder, Ciba Clinical Symposia 2 251-275)

OPERATIVE PROCEDURES FOR CALCIFIED DEPOSITS





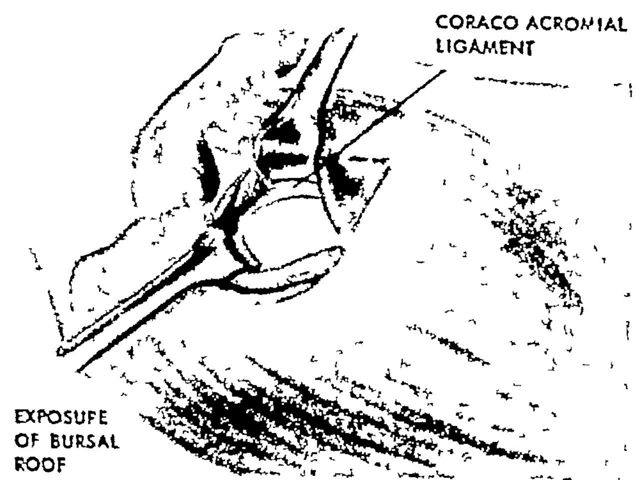


PLATE 20

Posterior Relations of the Scapula

This plate shows the superficial position of the scapula and the musculature related to its posterior surface

In the lower drawing are shown the muscles of the rotator cuff, which fill the supraspinous and the infraspinous fossae, as also their insertions with the teres minor on the greater tuberosity of the humerus They cover the suprascapular nerve which courses on their anterior surface and supplies the supraspinatus and the infraspinatus Below the teres minor is noted the circumflex nerve, a branch of which supplies the teres minor This nerve is also seen in the main drawing, appearing posteriorly after traversing the quadrilateral space

In the main drawing the scapula and the humerus have been placed in position on the thoracic cage On the right side are seen the muscles retaining the scapula in position and influencing the movements in the thoracoscapular mechanism These are the levator anguli scapulae and the rhomboids minor and major The teres major has also been added Deeply, and not visible, the powerful serratus anterior must be visualized

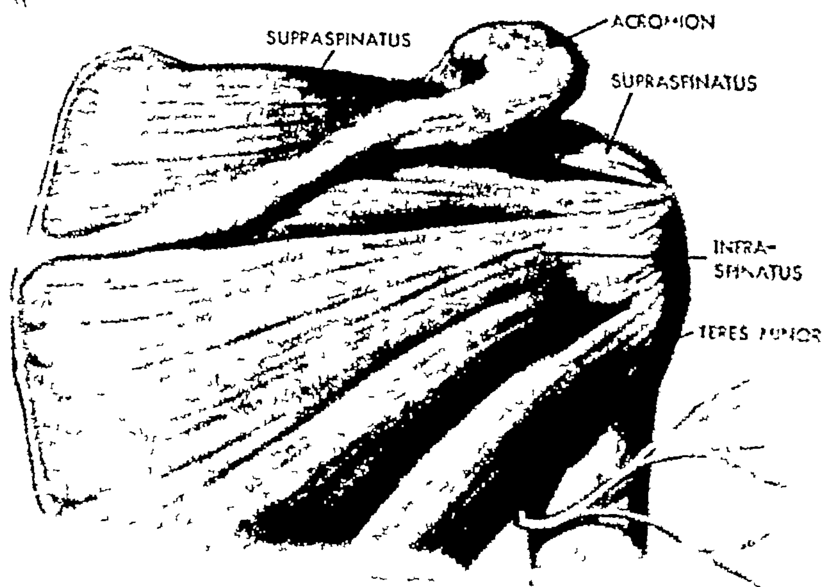
The musculature is completed by replacing the deltoid to its attachment on the spine of the scapula and superimposing the large flat muscle mass formed by the trapezius

From this plate it can be seen that the spine, the three fossae and the borders of the scapula are readily accessible to the surgeon, as shown in Plate 22

(Moseley, H F Disorders of the shoulder, Ciba Clinical Symposia 2 251-275)

LEVATOR SCAPULAE
RHOMBOIDEUS MINOR
RHOMBOIDEUS MAJOR
SUPRASPINATUS
INFRASPINATUS
TERES MINOR
ACROMION PROCESS
SUBACROMIAL BURSA
DELTOID
TRAPEZIUS
C7
T2
REFLECTED DELTOID
CIRCUMFLEX (AXILLARY) NERVE
TERES MAJOR
LONG HEAD OF TRICEPS
LATERAL HEAD OF TRICEPS
T12
LATISSIMUS DORSI
LATISSIMUS DORSI

THE SHOULDER DISSECTED FROM THE REAR



DETAIL WITH BURSA REMOVED TO SHOW INSERTION OF SUPRA- AND INFRA-SPINATI IN FORMATION OF ROTATOR CUFF

F. Netter M.D.

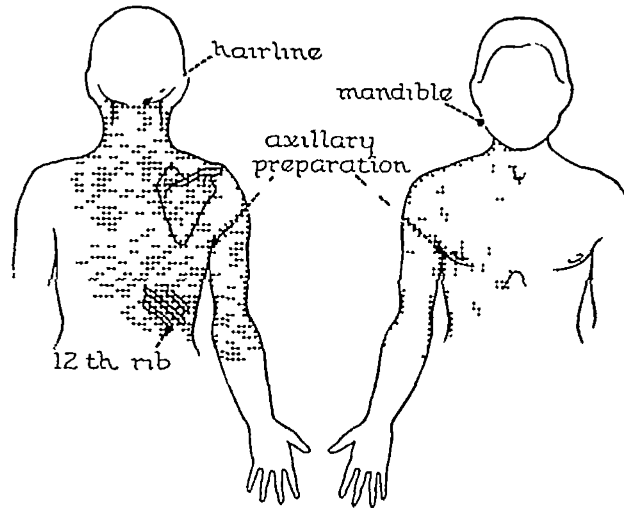


Fig 17 Area of skin preparation for operative procedures on the scapula and the posterior aspect of the shoulder

The skin preparation for operative procedures on the region of the scapula and the posterior aspect of the shoulder joint must include, posteriorly, the whole of the surface of the neck to the hairline, the back down to the level of the twelfth rib, and well across the midline, as well as the whole surface of the scapular area Anteriorly, the skin over the neck to the mandible and down over the chest to the rib margin should be included

The limb is usually shaved to below the elbow, but if manipulation of the limb will be required, it is best to prepare the forearm and the hand

A most careful axillary toilet is essential



FIG 18 Posturing and draping for operative procedures on the scapula and the posterior aspect of the shoulder

(A) The patient is postured in a semiprone position A pillow is placed under the chest on the affected side An anesthetic screen is essential

(B) The orderly holds the hand while the foundation sheet is applied and while the four towels are placed to outline the operative field

(C) The hand and the wrist are received into a sterile towel, after which the whole limb is covered with stockinet

(D) A laparotomy sheet is used as a coverall after the limb has been passed through the opening which affords access to the operative field

PLATE 21

Exposures of the Scapula

The scapula does not frequently require operative exposure. Displaced fractures of the spine or the acromion, congenital deformity of the superior angle, osteomyelitis and neoplasm constitute the chief indications

This plate should be correlated with Plate 20, and together they provide the anatomic relationships which must be understood before approaching different areas of this bone

Figure A shows the patient postured for these exposures The incisions I and II can be used separately or joined into one when the whole posterior aspect of the scapula requires visualization

Figure B depicts the exposure of the spine of the scapula through incision I After division of the skin and the subcutaneous tissues, the aponeurosis of the trapezius and the deltoid on the scapular spine is divided The trapezius and the posterior deltoid are then separated, affording access to the spine The exposure can be extended laterally as required to uncover the acromion The adjacent supraspinous and infraspinous fossae can be inspected

In Figure C the incision II is added The trapezius is retracted both superiorly and medially The supraspinous and the infraspinous fossae have been partially exposed by subperiosteal reflection of the respective muscles arising from these areas of the scapula If required, the reflection can continue along the dotted line separating the rhomboids and the serratus anterior This will expose the vertebral border of the scapula By reflecting the subscapularis from the venter of the scapula, the subscapular fossa can also be exposed Further extensions for procedures in hand can be undertaken as required

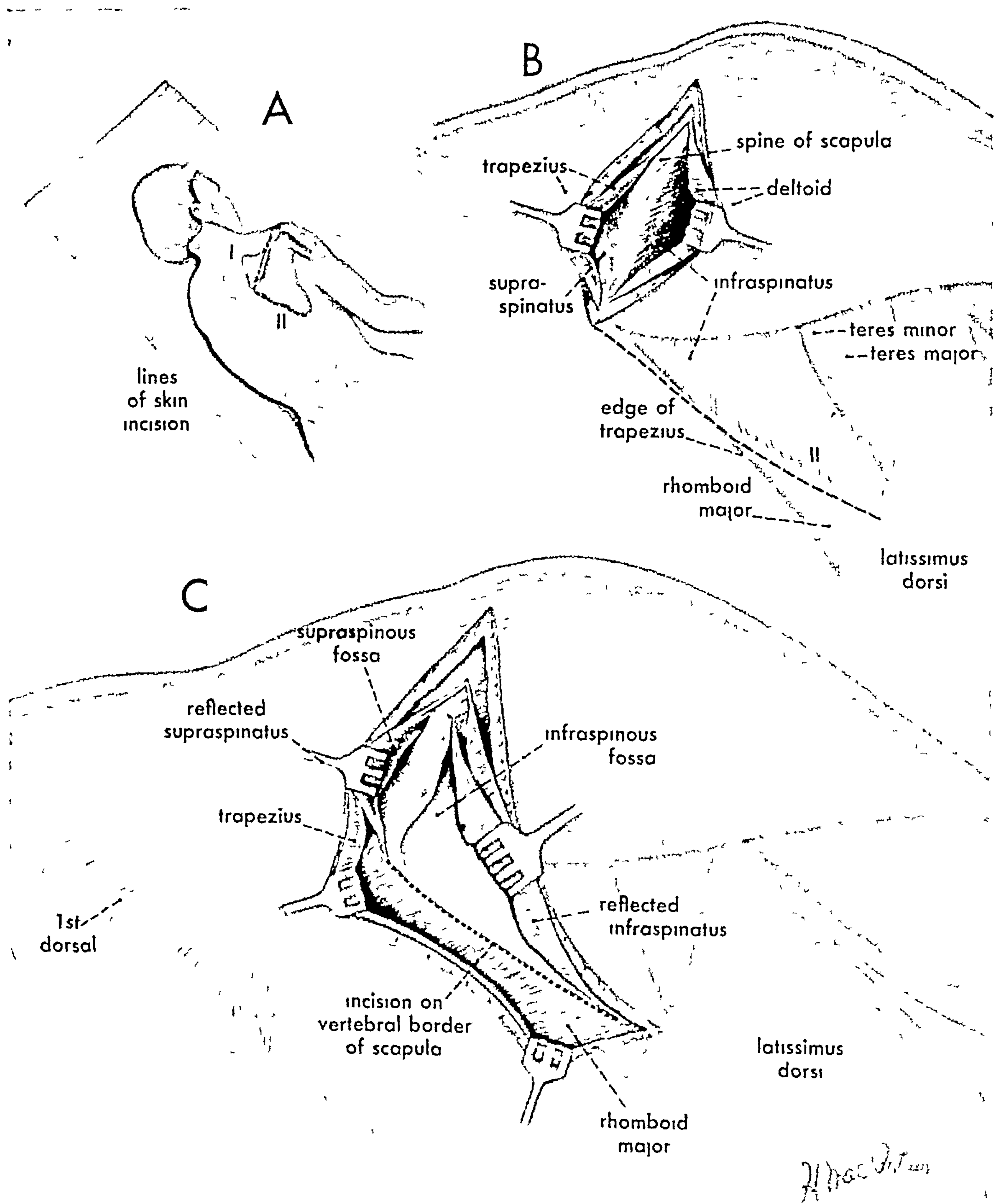

A
I
II
lines of skin incision
B
spine of scapula
trapezius
deltoid
supra-spinatus
infraspinatus
teres minor
teres major
edge of trapezius
II
rhomboid major
latissimus dorsi
C
supraspinous fossa
reflected supraspinatus
infraspinous fossa
trapezius
reflected infraspinatus
1st dorsal
incision on vertebral border of scapula
latissimus dorsi
rhomboid major

PLATE 22

Posterior Relations of the Glenohumeral Joint

The posterior aspect of the glenohumeral joint lacks the complexity of its anterior counterpart This is due to the absence posteriorly of structures corresponding to the neurovascular bundle and its many ramifications The posterior glenoid rim and its capsular attachment are much more superficially located and surgically accessible than the anterior glenoid rim and its capsular insertion, which are so deeply placed when exposed through the deltopectoral interval

In the orientating drawing a, the patient is visualized in the position for the posterior operative approach The positions of scapula, humerus and joint capsule are indicated The levator scapulae and the rhomboid minor and major muscles are shown

Figure b shows the addition of the supraspinatus, the infraspinatus and the teres minor with the bursa covering the tendinous cuff The teres minor and major form a triangular cleft which is crossed by the long head of triceps The circumflex nerve and vessels leave the axilla through the quadrilateral space between the triceps and the humerus and enter the deep surface of the deltoid

In c, the superficial muscles, the deltoid and the trapezius, have been added The triceps has also been completed The course of the circumflex nerve can be seen through transparent tissues The anatomic position of this nerve is the most important surgical landmark in the posterior exposure of the glenohumeral joint

(Moseley, H F An Atlas of Shoulder Dislocations, North Chicago, Abbott)

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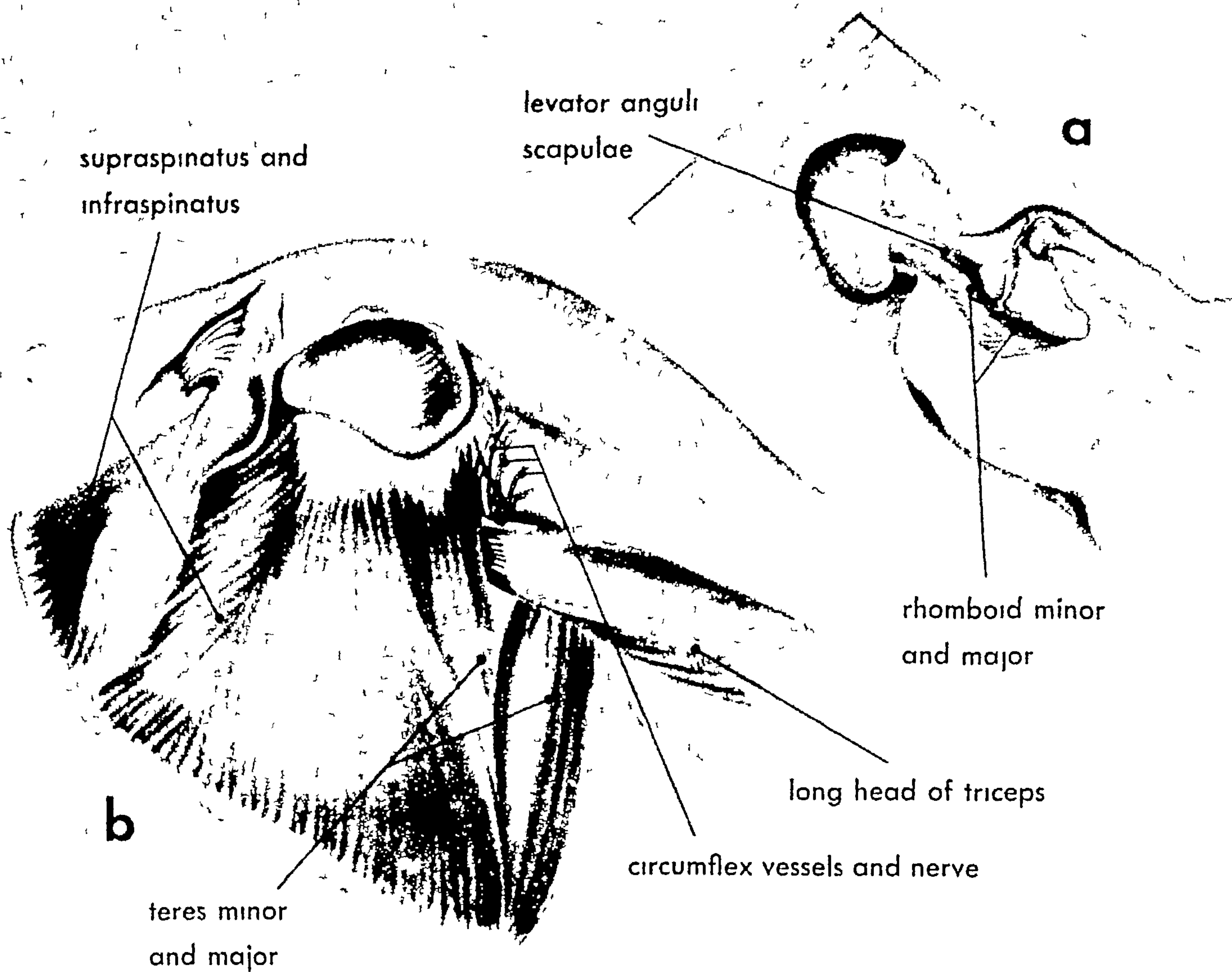

levator anguli
scapulae
a
supraspinatus and
infraspinatus
rhomboid minor
and major
long head of triceps
b
circumflex vessels and nerve
teres minor
and major
c
trapezius
deltoid

PLATE 23

The Posterior Exposure of the Shoulder Joint Employed for a Posterior Dislocation

The posterior exposure was described by Kocher, and its modifications are chiefly in the direction of the skin incision and the division of the posterior third of the deltoid

The orientating drawing a shows the line of incision in relation to the scapula and the posteriorly displaced humeral head

In b, the head is seen to be dislocated deep to the infraspinatus and the teres minor, corresponding to the position of the head in the anterior dislocation deep to the subscapularis The cross section indicates that the posttraumatic anatomy in these cases resembles that found in the anterior types In this case the labrum and the capsule are detached from the posterior rim but other patterns may be found

Figure c shows the posterior deltoid reflected and the infraspinatus and the teres minor stretched tautly over the bony prominence of the dislocated head The line of arthrotomy is shown. The surgeon must have knowledge of the position of the circumflex nerve (Plate 22), as it is not necessarily exposed during the operation

When the joint is opened and the dislocation reduced (d), the torn and fragmented labrum, with the pouch formed by the stretched capsule, can be visualized The further operative steps correspond to the Bankart repair (Plate 14) and include the suture of capsule to raw bone

(Moseley, H F An Atlas of Shoulder Dislocations, North Chicago, Abbott)

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3¼ reels, 16 mm , sound color

Procurable from Central Office Film Library, Veterans Administration, Vermont Ave and H St , N W , Washington 25, D C

2 Surgical Anatomy of the Shoulder The Diagnosis and Surgical Treatment of Shoulder Lesions (shows dissection of shoulder from posterior, superior, anterior and lateral aspects supplemented by animated drawings) (1952) (By H F Moseley, M D , Montreal)

2 reels, 16 mm , silent color *

3 Calcified Deposits in the Rotator Cuff (1948) (By H F Moseley, M D , Montreal)

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4 Anterior Dislocations of the Shoulder (1949) (By H F Moseley, M D , Montreal)

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3 reels, 16 mm , silent color *

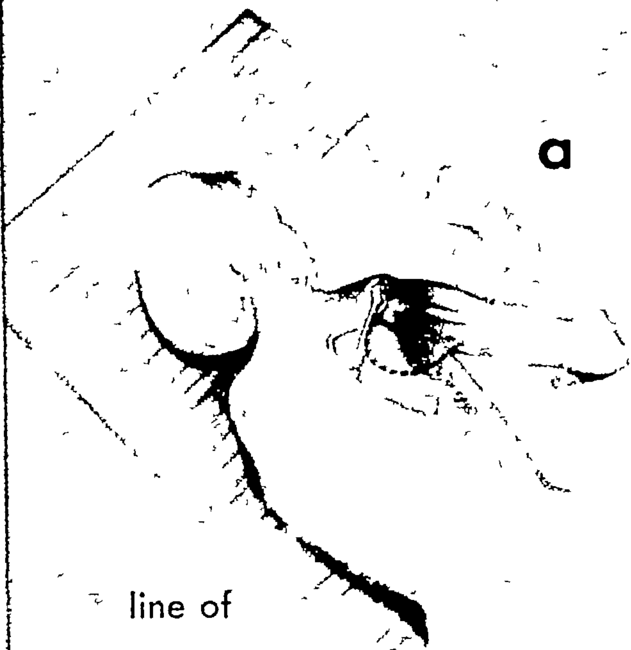
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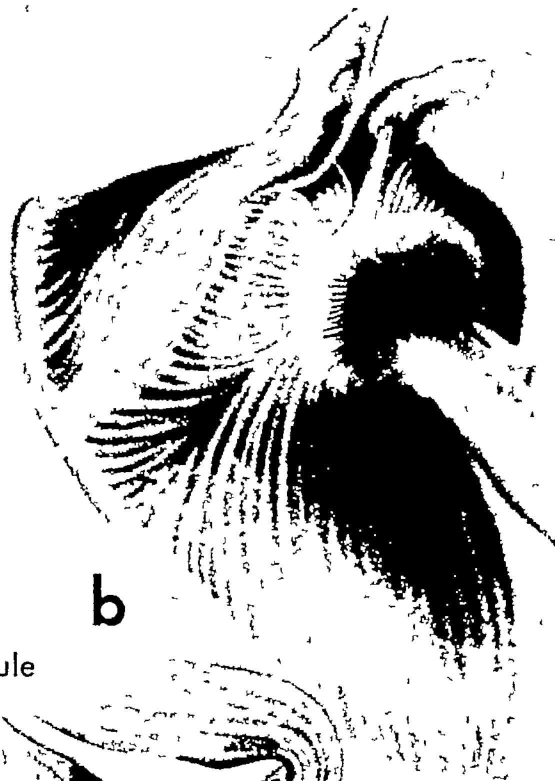
1¼ reels, 16 mm , silent color *

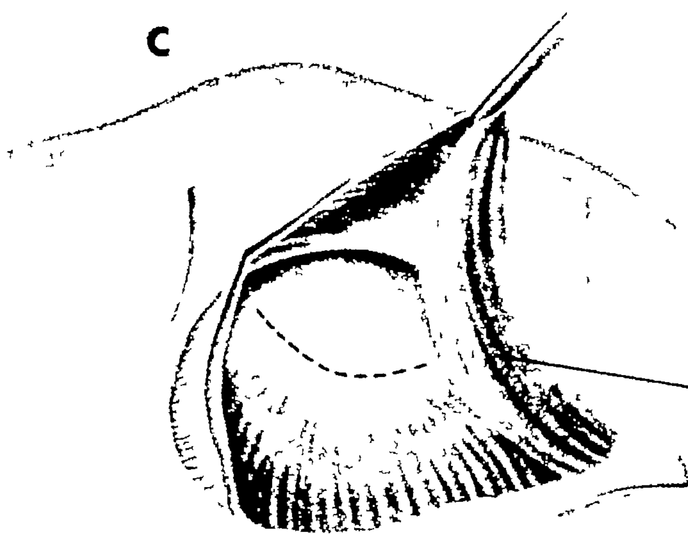
7 Biceps Tendon Transference for Recurrent Dislocation of the Shoulder (depicts the Nicola technic for repair of recurrent dislocation of the shoulder using the long head of the biceps and a strip of the coracohumeral ligament for repair) (1950) (By Toufick Nicola, M D , Montclair)

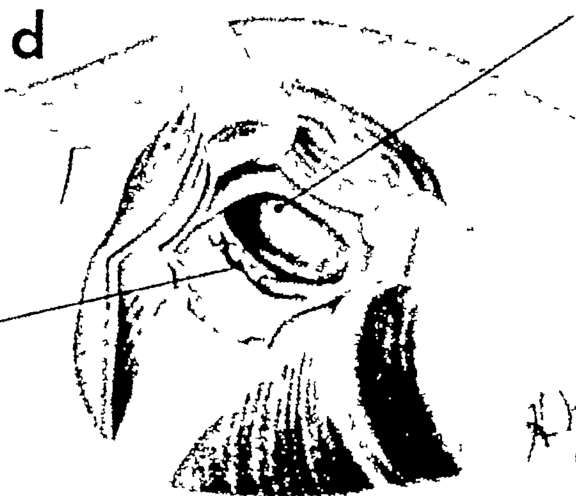
2 reels, 16 mm , silent color *

* Procurable from Davis & Geck, Inc , 1 Casper St , Danbury, Conn


a
line of
incision


b
detached capsule
subscapularis
infraspinatus


c
reflected deltoid
line of arthrotomy
in posterior cuff


d
head of humerus
torn labrum and capsule
after reduction

5
THE ARM

Traumatic and orthopedic surgeons perform operations on the *arm* largely for fractures of the humerus or ruptures of the biceps brachii This section deals chiefly with these two aspects of the subject, as the exposures of the *upper end of the humerus* are treated in the preceding section, while the exposures for the *lower end of the humerus,* including its posterior aspect, and the elbow are included in the section which follows Displaced fractures of the *humeral shaft,* with and without injury to the radial nerve, pathologic fractures through cysts or neoplasms, nonunion of fractures requiring bone grafting, osteomyelitis and neoplasms may also necessitate exposure of the shaft

The diaphysis of the humerus is well covered in the muscular patient The bulky triceps affords a barrier posteriorly, the neurovascular bundle is placed medially, and the biceps and the brachialis intervene between skin and bone anteriorly This leaves the lateral and the anterolateral aspects as best suited for our approach The older writers, such as Kocher, recognized this fact and described an anterolateral approach, but most present-day authors give credit to Thompson and Henry, who have detailed the anatomic relationships and the steps in this exposure The author accepts this anterolateral exposure described by Thompson and Henry as the standard approach to the shaft of the humerus

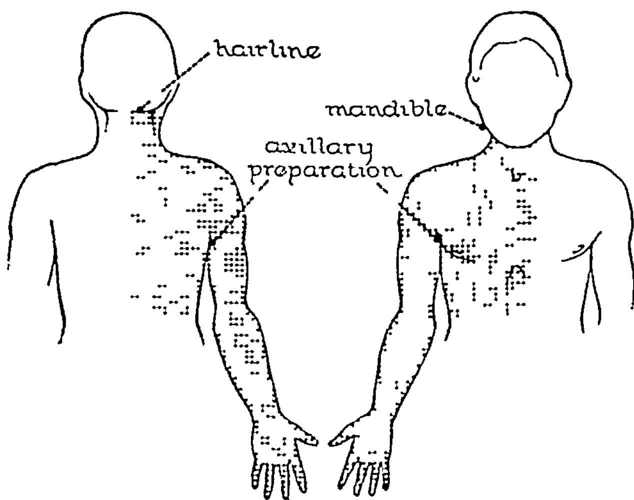
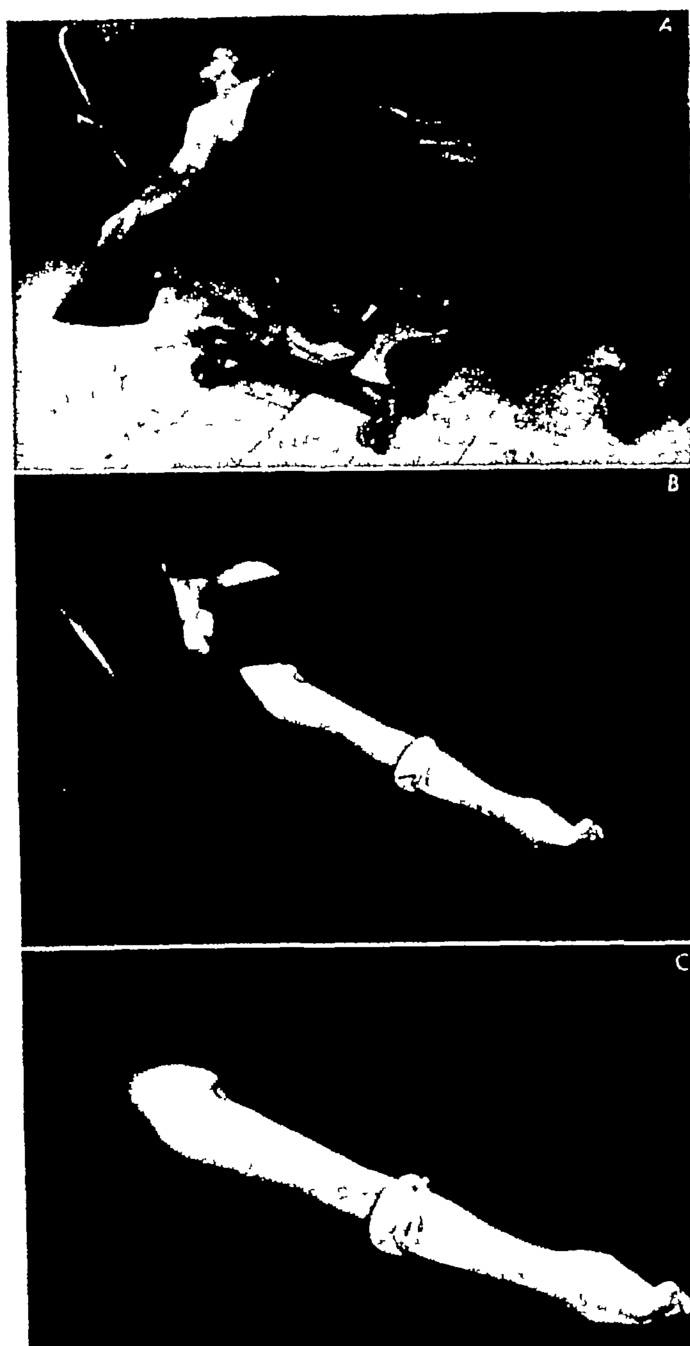


FIG 19 Area of skin preparation for operative procedures on the arm

The area of skin preparation for operative procedures on the arm best includes the whole limb If preferred, the hand and the fingers can be omitted, as the draping can cover this omission

The trunk and the neck are prepared beyond the mid-line anteriorly and posteriorly, with upward extension to the hairline and the mandible

The axilla requires meticulous shaving and cleansing



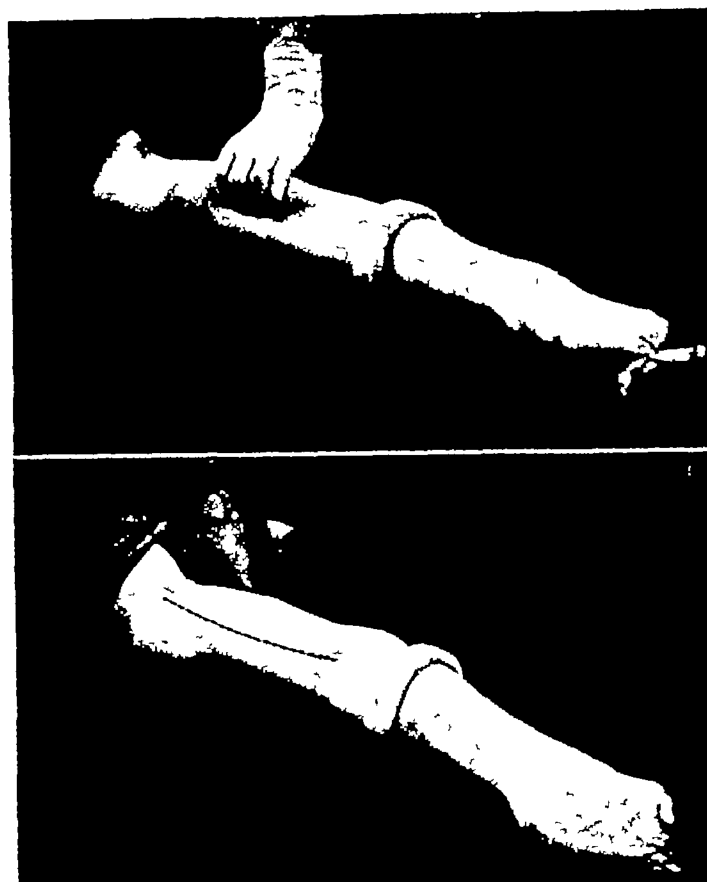


FIG 20 Posturing and draping for operative procedures on the arm

(A) The patient lies supine The upper limb rests on a padded arm rest or small table placed at an angle of 70° to the body An anesthetic screen is used

(B) The limb is supported at the wrist by an orderly while the foundation draping of the body and the arm rest is placed The hand and the wrist are received into a sterile towel, and this is covered by stockinet to the elbow The four towels of the operative field are laid

(C) A laparotomy sheet is used as a coverall after the limb is passed through the opening

(D) A close-up photograph shows the posturing and the draping completed The surgeon localizes the biceps muscle as shown He is thus able to visualize his incision, which runs along its lateral edge

(E) The incision for the anterolateral approach to the humerus is indicated

PLATE 24

Anterolateral Exposure of the Humerus

Fractures of the humeral shaft are sometimes associated with injury to the radial nerve Exploration of the nerve, followed by reduction and internal fixation of the displaced fragments, may be indicated Some surgeons favor this treatment when soft tissues prevent adequate closed reduction The most useful approach is that from the anterolateral aspect The surgical anatomy of this exposure is illustrated in this plate

In a, the skeletal framework comprising the humerus, the upper ends of the radius and the ulna, together with the intervening articulation, is depicted The attachments of the important muscles, namely, the deltoid, the brachialis anterior, the coracobrachialis on the humerus, and the supinator, the biceps brachii and the brachialis on the radius and the ulna, are indicated

Figure b shows the addition of these muscles The brachialis anterior covers the lower two thirds of the humeral shaft on its anterior aspect, extending over the capsule of the elbow joint and inserting on the ulna The insertions of the deltoid and the coracobrachialis are closely related to the upper portion of the brachialis anticus

Four important nerves are shown The radial nerve is the most significant in this exposure and is seen posterolateral to the deltoid insertion, lying on the lateral head of the triceps This nerve courses downward, becoming more anterior in position and lying between brachialis anterior and brachioradialis At the level of the joint it divides into superficial and deep branches The deep branch winds round the neck of the radius within the supinator muscle and appears posteriorly as the dorsal interosseous nerve The musculocutaneous nerve pierces the coracobrachialis, descends between the brachialis anterior and the biceps brachii, and is attached to the fascia on the latter muscle This nerve supplies these three muscles, to which it is so closely related The median and the ulnar nerves with their relations to the brachial vessels are also shown

In c, the biceps brachii, the deltoid and the pectoralis major have been added to complete the musculature of the arm, but the origins of the forearm muscles were omitted for clarity

The anterolateral exposure represented by d, e and f can be understood readily after a study of a, b, and c It is really a continuation of the anterior deltopectoral exposure of the shoulder joint and the upper end of the humerus The incision shown in d runs from the anterior aspect of the deltoid insertion along the outer edge of the biceps brachii, and at the level of the elbow stays close to the lateral edge of the biceps tendon In the lower part, the lateral cutaneous nerve of the forearm, which represents the terminal sensory component of the musculocutaneous nerve, must be protected as it leaves the cover of the biceps muscle

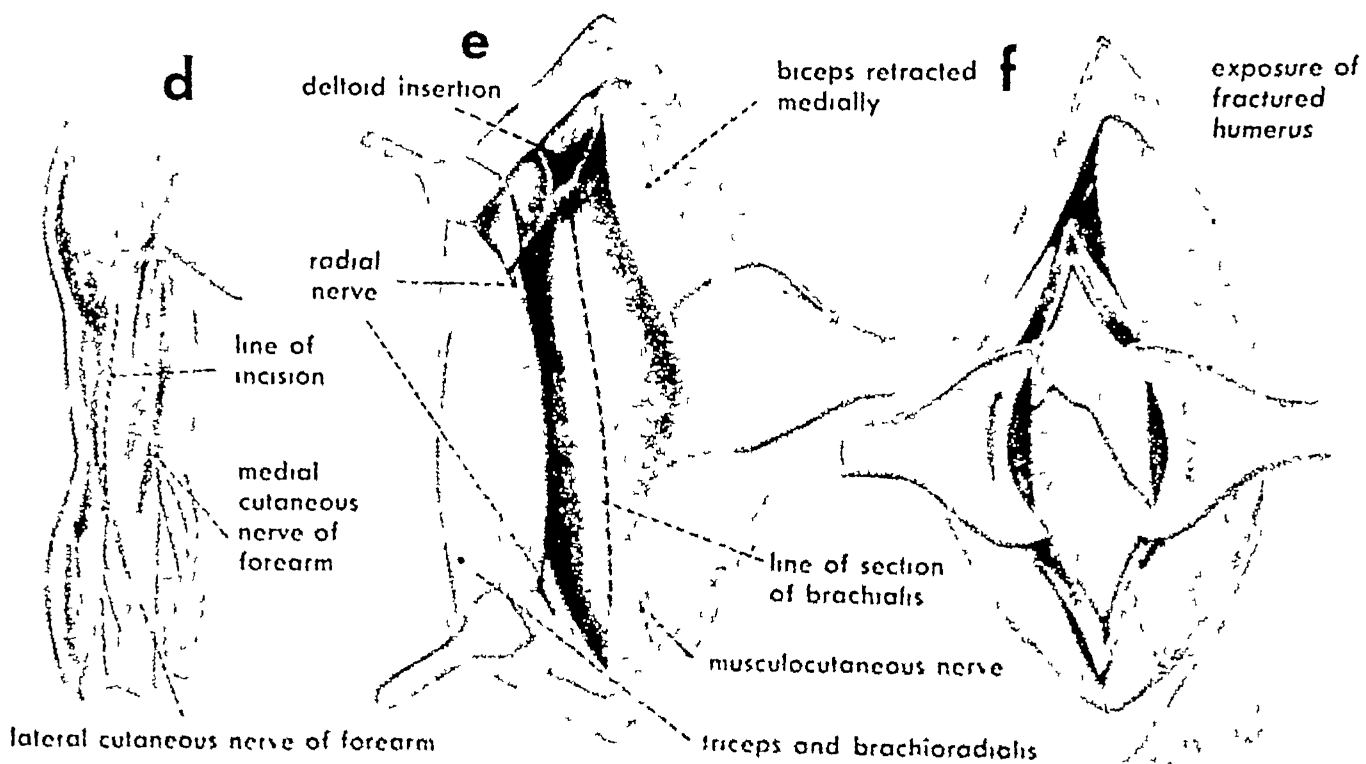
With section of the deep fascia along the lateral edge of the biceps brachii, this muscle can be retracted medially, exposing the brachialis anterior The lateral portion of the brachialis muscle is sectioned to the bone in the direction of its fibers, and the humeral shaft is exposed

In e, the radial nerve is diagrammatically represented in two places Superiorly, it is seen posterolateral to the deltoid insertion Here it is deeply placed between the triceps and the brachialis anterior Inferiorly, it is seen lying between brachioradialis and brachialis anterior, where it is the more easily recognized When necessary, it can be isolated and examined for injury in this portion of its course

Figure f completes the exposure of a fracture of the mid-shaft of the humerus It must be understood that this incision can be extended upward anterior to the deltoid insertion to visualize the upper end of the humerus and downward across the elbow into the anterior exposure for the radius when the case demands such extensions The reader is referred to Plates 12 and 26

(Moseley, H F An Atlas of Surgical Exposures, North Chicago, Abbott)

a
b
c
musculocutaneous nerve
pectoralis major
deltoid
deltoid
long and short biceps
coraco brachialis
coracobrachialis
brachialis
median nerve
biceps
triceps
brachial artery
triceps
radial nerve
biceps and bursa
brachioradialis
ulnar nerve
brachialis
supinator
supinator
ulnar nerve



d
e
f
deltoid insertion
biceps retracted medially
exposure of fractured humerus
radial nerve
line of incision
medial cutaneous nerve of forearm
line of section of brachialis
musculocutaneous nerve
lateral cutaneous nerve of forearm
triceps and brachioradialis

PLATE 25

Exposure and Repair of Ruptured Long Tendon of Biceps

An operative exposure of the bicipital groove and of the retracted distal end of the ruptured long tendon of the biceps is required in the younger worker whose tendon has been ruptured as the result of sudden violent strain In these cases, not only is the tendon disrupted but it is drawn down on to the belly of the muscle, and the distal end must be approached by a separate incision For a varying period, between 4 and 6 weeks, suture may be performed with excellent results After this period, contracture of the muscle belly and fixation of the tendon may render restoration of position and suture impossible

The bicipital groove is exposed by incision I, as in A, placed more anteriorly than the lateral approach for a calcified deposit The deltoid is separated in the direction of its fibers, and the bicipital groove is exposed The rotator cuff is explored, as frequently it is found to suffer a concomitant complete rupture, or the bicipital lesion may be secondary to an attritional change in the overlying cuff Such cuff changes may necessitate a plastic repair

In certain cases, the bicipital groove is empty, and the distal end of the long tendon cannot be found In others, the tendon sheath is found, and by traction the tendon end can be drawn up into the wound and sutured When the distal end has retracted, a separate incision, II, just anterior to the deltoid insertion and below the pectoralis major insertion on the lateral lip of the bicipital groove, will expose the ruptured tendon rolled up in a fibrinous mass When healing has progressed, the bulbous end must be removed, as shown in B and C, and a suture is placed in the cut end An eyed probe is passed down the bicipital groove deep to the pectoralis major tendon, the suture is threaded and the bicipital tendon is drawn up fairly taut into its groove After roughening the floor of the groove, the tendon is fixed in position by mattress sutures in the bony lips of the groove This position of fixation is in line with the natural pull of the tendon and appears to be preferable to suture to the short head of the biceps or to the coracoid process, as suggested by Gilcreest

Remarks The exposure through incision I can be used for operative procedures for recurrent dislocation and tendinitis of the biceps tendon, for the Nicola operation, and for operations on the adjacent cuff The split in the deltoid must not exceed 2 inches, otherwise the nerve supply to the anterior deltoid fibers arising from the circumflex nerve will be divided

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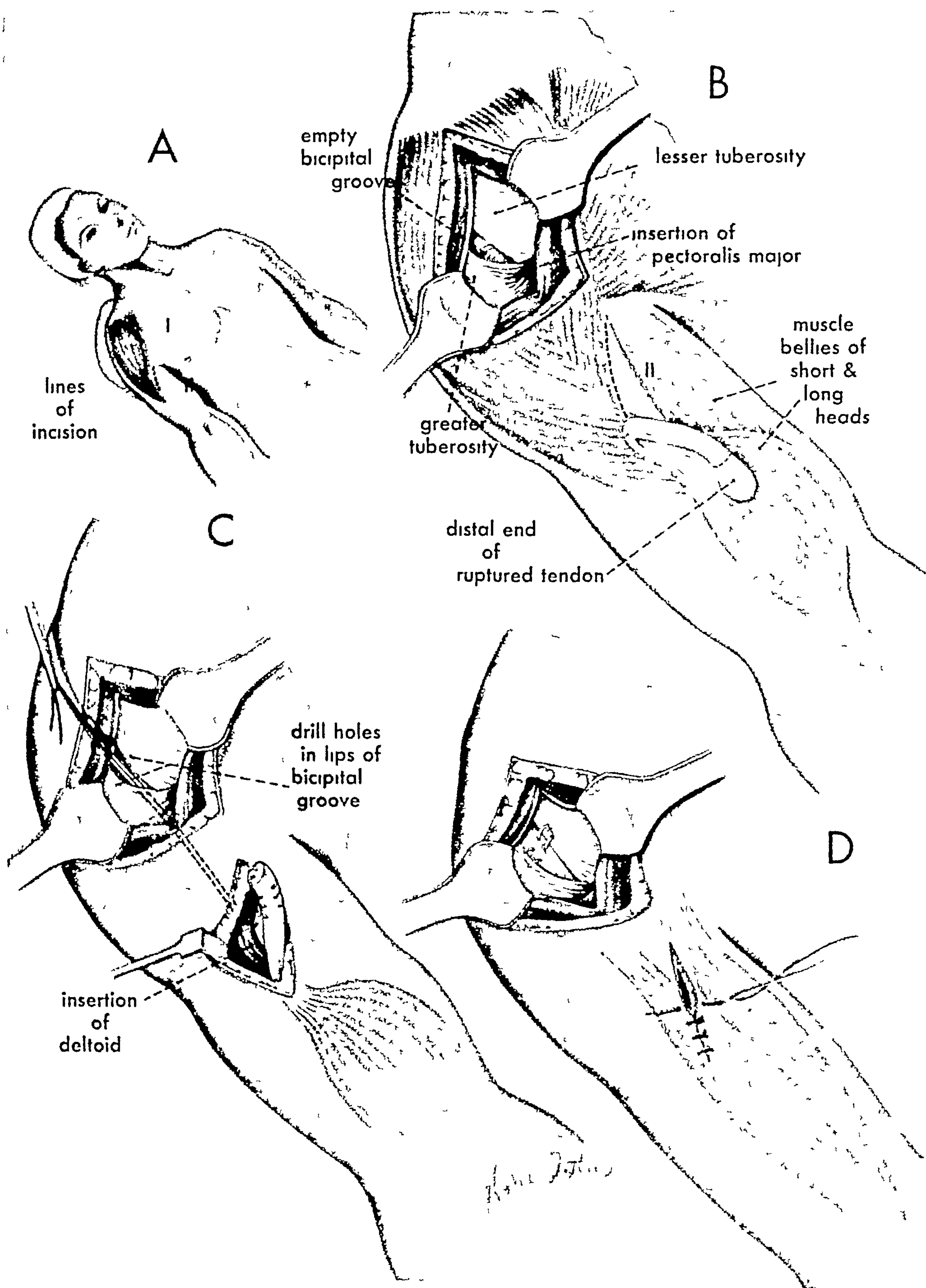
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—— Anatomical methods of approach in operations on the long bones of the extremities, Ann Surg **68** 309-329, 1918


A
lines of incision
B
empty bicipital groove
lesser tuberosity
insertion of pectoralis major
muscle bellies of short & long heads
greater tuberosity
distal end of ruptured tendon
C
drill holes in lips of bicipital groove
insertion of deltoid
D

6

THE ELBOW

The *elbow* is subject to many injuries requiring operative intervention These may be caused by direct violence, or they may be transmitted indirectly from forces applied to the hand and the wrist This complicated joint, comprising two main types of mechanism of the hinge and the pivotal types, is quickly deranged by the forces above mentioned which tend to produce fractures extending through the articular surfaces Thus fractures of the radial head tend to damage the pivotal mechanism, limiting pronation and supination, while fractures of the lower end of the humerus and olecranon involve the hinge mechanism with subsequent limitation of the range of flexion and extension

Secondary changes such as myositis ossificans, Volkmann's ischemic contracture, tennis elbow, secondary ulnar palsy, loose bodies in the joint and many others may necessitate operative procedures on this area Old dislocations of the elbow, seen less frequently than formerly, may require posterior exposure and reduction The same exposure may be used for arthroplastic procedures Primary open reduction and internal fixation is often the treatment of choice for the Monteggia fracture-dislocations, and this is best performed through the posterolateral approach described by Boyd

Anatomically, the joint is deeply placed on its anterior aspect Here the antecubital fossa forms its roof, in which course the medial and the lateral cutaneous nerves of the forearm, running with branches of the basilic and the cephalic veins so frequently used for venipuncture The key localizing structure in the antecubital fossa is the biceps tendon, medial to which lie the brachial artery and vein, and then the median nerve, while lateral to the tendon the radial nerve passes deeply just superficial to the joint capsule

Posteriorly, the landmarks are superficially placed and easily localized The tip of the olecranon, as well as the medial and the lateral epicondyles, is visible and palpable These three points make triangles of varying shapes in the different positions of flexion and extension of the joint.

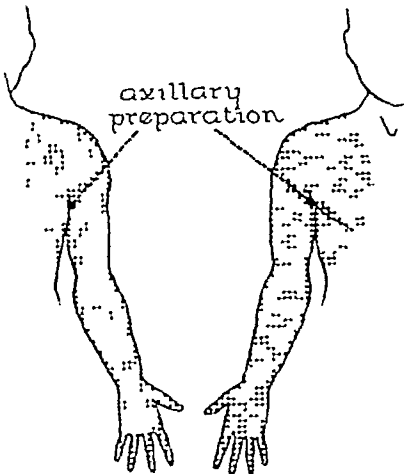


FIG 21 Area of skin preparation for operative procedures on the elbow

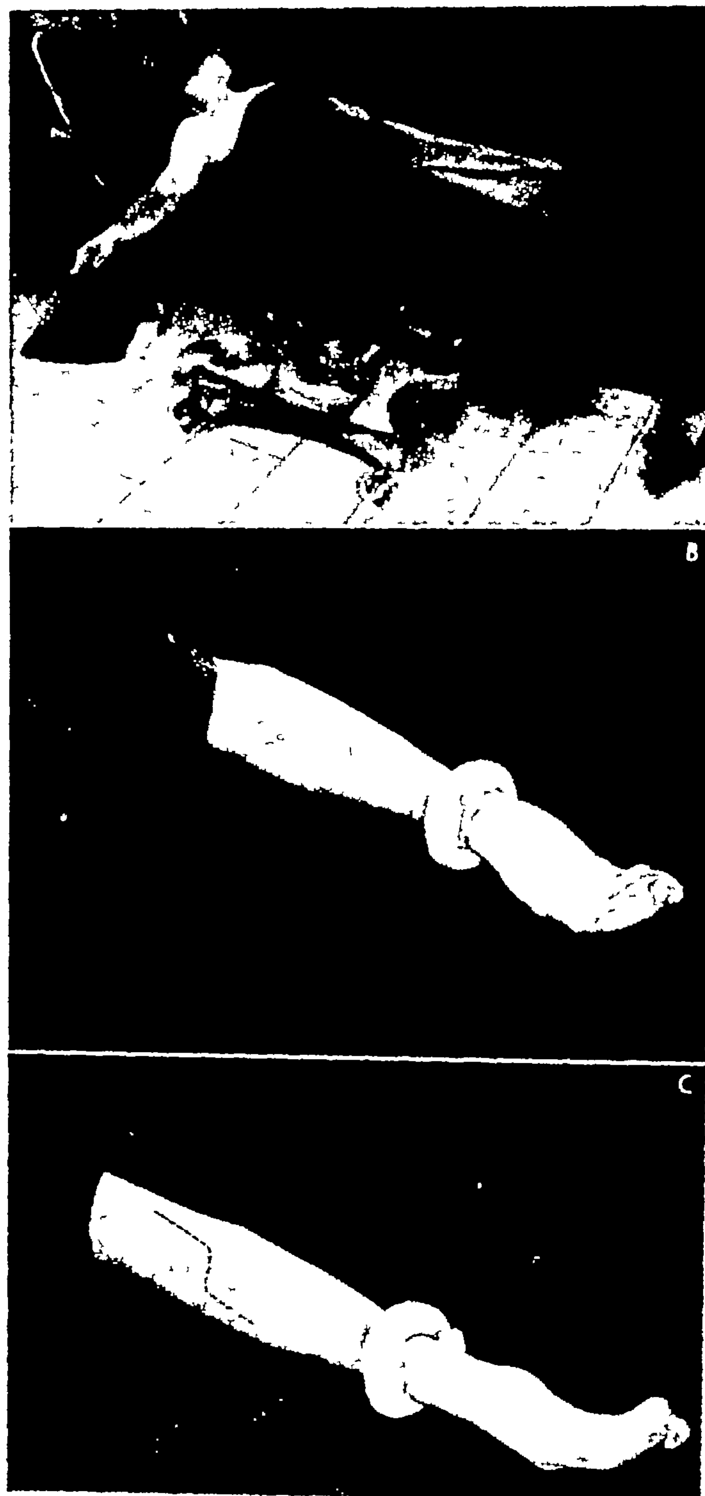
The area of skin preparation for operative procedures on the joint of the elbow, the component bones and adjacent soft tissues best includes the whole limb and shoulder region If desired the hand and the fingers may be omitted and this omission obviated by the separate draping of this area Careful attention must be given to the axillary preparation

FIG 22. Posturing and draping for the anterior exposure of the elbow

(A) The patient is postured in the supine position with the upper extremity extended on a padded arm rest or small table arranged at an angle of 70° to 80° to the trunk If indicated or desired, the limb is first elevated and an Esmarch bandage is applied from the hand to afford a bloodless field After the pressure has been secured, the Esmarch bandage is removed and the skin painting is carried out

(B) The foundation draping of the trunk, the lower limbs and the arm rest is arranged, followed by the application of a towel in circular manner round the arm to delimit the field superiorly The hand and the wrist are then received into a sterile towel, which is covered by stockinet extending superiorly as required

(C) The limb is passed through the opening in a laparotomy sheet which is used as a coverall



Posteriorly and laterally, the head of the radius can be palpated This landmark is best identified while the forearm is pronated and supinated

Medially, the ulnar nerve can be rolled in its groove behind the medial epicondyle The position of the nerve must be determined and its isolation effected in most operations on the posterior aspect of the joint Its position is indicated in Plates 26 and 27 The medial approach for removal or fixation of the displaced medial epicondyle and the operative procedure for transposition of the ulnar nerve, however, are not covered in this series

It can be seen from the above that the joint structures are most readily exposed from the posterior and the lateral aspects Special attention has been devoted to the relationships and the approaches from these directions The anterior approach also included is utilized for such lesions as myositis ossificans and avulsion of the biceps tendon

Most operations on the elbow region are best carried out in a bloodless field secured by the use of the Esmarch bandage and pneumatic tourniquet.

PLATE 26

Anterior Exposure of the Elbow Joint

The anterior relations of the elbow joint illustrated in this plate must be reviewed when the surgeon intends to visualize the anterior capsule, explore the capitellar surface of the humerus or the head of the radius, resuture the avulsed biceps tendon, excise a myositis ossificans in the brachialis anterior insertion or detach the supinator to expose the upper third of the radius The joint space and the articulating bones anteriorly are deeply placed and, therefore, when required, a posterior, a lateral or a medial approach is more frequently considered

Figures a, b and c show the soft tissues superimposed The brachialis anterior is the muscle covering closely the anterior aspect of the humeral shaft and the capsule as it extends to insert on the coronoid process of the ulna The supinator muscle similarly invests the upper portion of the radius The complicated origin of the flexor digitorum sublimis must also be noted at this time

Of the four nerves shown, the radial nerve is the most important in the approach under consideration It passes downward, as noted in Plate 24, closely applied to the lateral border of the brachialis Its course is over the radial side of the capsule to the surface of the supinator, on which it divides into the superficial and deep branches

Just medial to the nerve is the insertion of the biceps tendon on the radial tuberosity This tendon is the landmark separating the radial nerve laterally from the brachial vessels and the median nerve medially In c, the superficial muscles and the elaborate system of veins in the antecubital fossa, so important in venipuncture, are added

Figures d and e illustrate the exposure This is seen to be a continuation of the anterolateral exposure of the humerus (Plate 24) and runs into the anterior approach to the radius (Plate 29) In order to avoid the pernicious longitudinal scar, an oblique incision across the joint is employed

Once the deep fascia is visualized, deeper dissection proceeds along the lateral border of the biceps muscle and tendon The terminal cutaneous branch of the musculocutaneous nerve is located and protected The deep fascia is incised and the biceps muscle with tendon is retracted inward The radial nerve is carefully isolated and protected by retracting it outward Further procedures are governed by the surgery required The joint may be opened by a vertical incision exposing the radiohumeral articulation The site of the biceps insertion may be found and an avulsed tendon resutured The upper end of the radius may be bared by subperiosteal reflection of the supinator, care is taken to begin this reflection medially close to the biceps insertion, extending laterally only after the position of the radial nerve has been located

(Moseley, H F An Atlas of Surgical Exposures, North Chicago, Abbott)

a

deltoid
coracobrachialis
brachialis
common extensor origin
common flexor origin
brachialis
biceps
supinator
anterior interosseous artery and nerve
pronator teres

b

deltoid
coracobrachialis
musculo-cutaneous nerve
brachialis
triceps
median nerve
radial nerve
brachial artery
ulnar nerve
supinator
biceps
medial and lateral cutaneous nerves of forearm
flexor digitorum sublimis

c

cephalic vein
basilic vein
triceps
pronator teres and common flexors
brachioradialis and common extensors

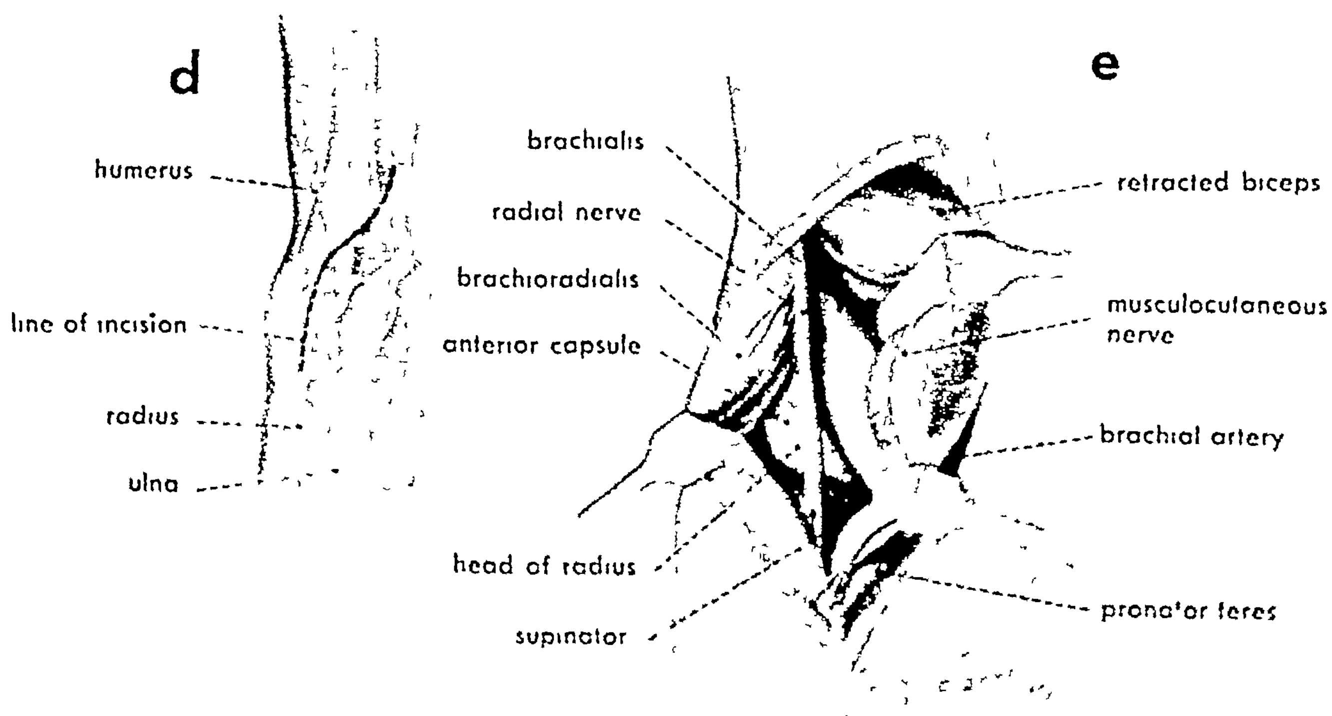


PLATE 27

Posterior Exposures of Lower End of Humerus and Olecranon

Figures a, b and c depict the important structures directly related to the posterior aspect of the elbow joint and of its component bones, the lower portion of the humerus and the upper ends of the radius and the ulna

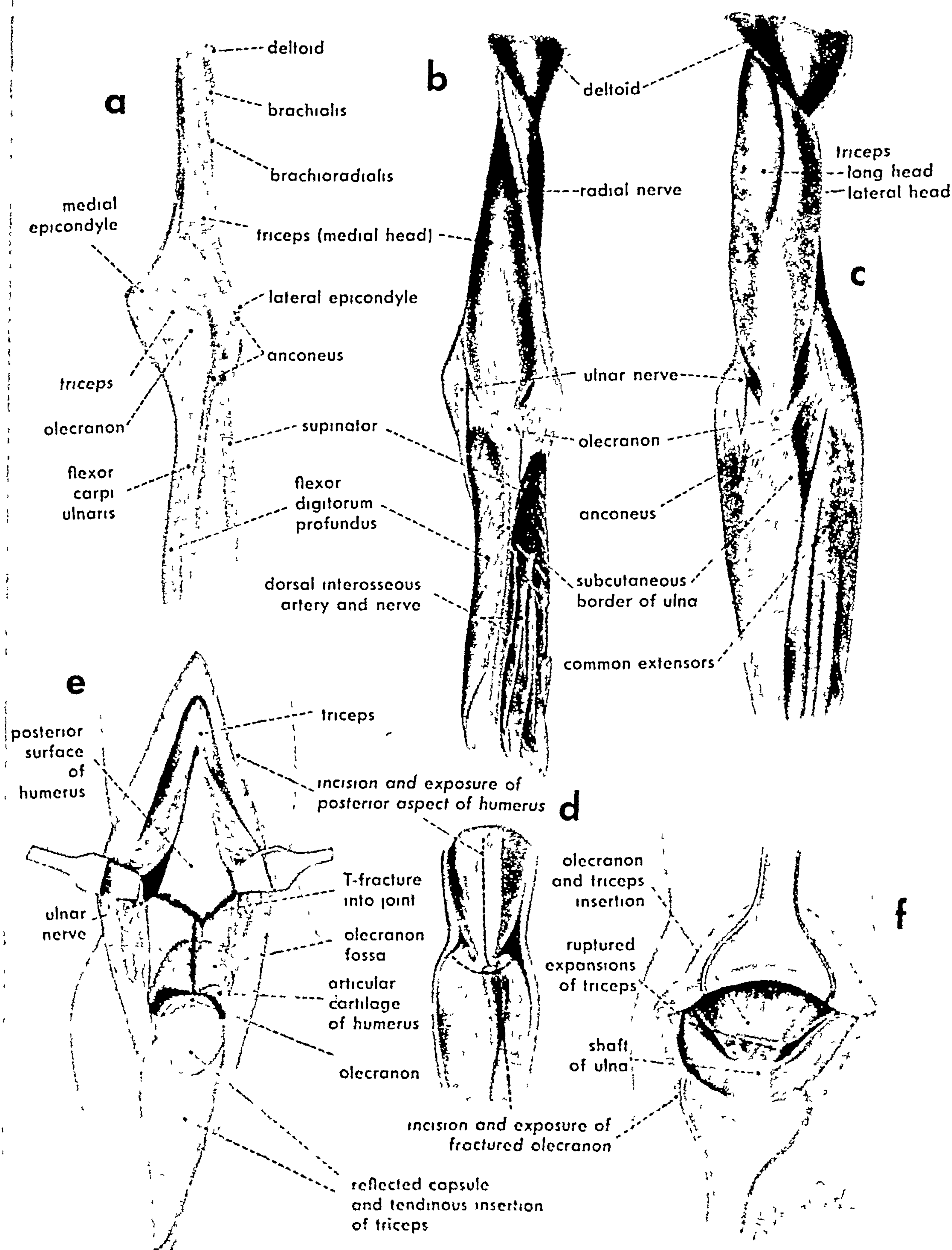
On the humerus, the medial head of the triceps constitutes the deep muscular layer Running along its superior border in a shallow groove is the radial nerve Passing laterally, this nerve pierces the lateral intermuscular septum and appears anteriorly, as has been seen in Plates 24 and 26 The radial nerve is noted again in b emerging from the supinator as the dorsal interosseous nerve Two other deep muscles are shown in b in relation to the radius and the ulna, namely, the supinator and the origin of the flexor digitorum profundus On the medial side of the joint, the ulnar nerve crosses on the posterior surface of the medial epicondyle Recognition of the ulnar nerve is most important in all posterior exposures at the level of the elbow joint

In c, the musculature of the arm and the forearm is complete The lateral and the long heads of the triceps have been added The extensor group from behind forward are in sequence—the anconeus, the extensor carpi ulnaris, the extensor digiti quinti, the extensor digitorum communis, the extensors carpi radialis longus and brevis and, finally, the origin of brachioradialis On the medial side can be seen the posterior portion of the flexor mass comprising the flexor carpi ulnaris and the flexor digitorum sublimis

Figure e illustrates one of the posterior exposures to the lower end of the humerus The incision for this exposure, indicated in d, is a median longitudinal incision of four or more inches extending to the tip of the olecranon The skin flaps are undercut and retracted, exposing the tendinous portion of the triceps This is sectioned at the periphery to give a tongue-shaped flap In the superior portion, the tendinous tissue is relatively thin and must be dissected from the underlying muscle fibers In the area near the joint, however, the full thickness of the triceps is tendinous With the flap reflected distally, the muscle fibers of the triceps are divided in the midline and are retracted to each side This exposes the posterior surface of the lower end of the humerus which, in this case, presents a Y fracture into the joint This is an excellent approach for comminuted fractures involving the lower end of the humerus The important structure to recognize and preserve from injury is the ulnar nerve, as seen adjacent to the retractor on the medial side

Fractures of the olecranon can be readily explored because of the superficial position of this bone Various incisions can be employed, but a curved transverse incision is chosen, as indicated in d Figure f shows the exposure of the fractured olecranon which has separated moderately and presents the typical tears of the lateral expansions of the triceps Suture of the ruptured expansions and of the central portion can be secured by fixation of the bone fragments Comminuted fragments can also be excised Again the ulnar nerve is illustrated to remind the surgeon of its position in the posterior exposures

(Moseley, H F An Atlas of Surgical Exposures, North Chicago, Abbott)



a
deltoid
brachialis
brachioradialis
medial epicondyle
triceps (medial head)
lateral epicondyle
anconeus
triceps
olecranon
supinator
flexor carpi ulnaris
flexor digitorum profundus
b
deltoid
radial nerve
ulnar nerve
olecranon
anconeus
subcutaneous border of ulna
dorsal interosseous artery and nerve
common extensors
triceps
long head
lateral head
c
e
triceps
posterior surface of humerus
incision and exposure of posterior aspect of humerus
T-fracture into joint
ulnar nerve
olecranon fossa
articular cartilage of humerus
olecranon
reflected capsule and tendinous insertion of triceps
d
olecranon and triceps insertion
ruptured expansions of triceps
shaft of ulna
incision and exposure of fractured olecranon
f

PLATE 28

Posterolateral and Lateral Exposures of the Upper Ends of the Ulna and the Radius

Fractures of the radial head frequently require exploration and removal of the entire head or small loose fragments Monteggia fracture-dislocations of the ulna and the radius are uncommon, but primary reduction and internal fixation of the fractured ulna with repair of the orbicular ligament are generally accepted as the ideal treatment

The anatomic relations of the elbow joint are illustrated from the posterolateral aspect in Figures a, b and c The ulnar nerve cannot be seen, but the radial nerve, which is of chief significance in all operative procedures on the radial head, can just be seen on the anterior aspect of the radiohumeral capsule as it passes downward and divides into its two branches on the surface of the supinator muscle The deep branch pierces the supinator and passes obliquely downward and backward, as shown in b This nerve is placed approximately ½ to ¾ inch below the inferior border of the radial head when approached from the lateral aspect, as indicated in Figure f

Figures d and e illustrate the incision and the exposure described by Boyd for the upper end of the ulna which can be extended to expose the radial head

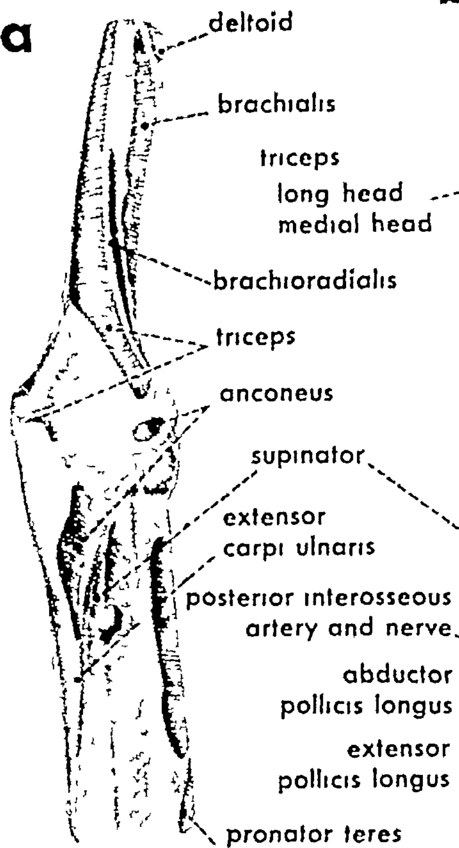
The incision extends for a short distance above the joint along the lateral border of the triceps, thence downward along the subcutaneous border of the ulna This could be continued into the posterior approach to the ulna (Plate 30) Subperiosteal reflection of the anconeus and the extensor carpi ulnaris is followed by reflection of the supinator when required When the fracture of the ulna is located, further exposure may be secured by reflecting the flexor carpi ulnaris and the flexor digitorum profundus from the posteromedial surface of the ulna (Plate 30)

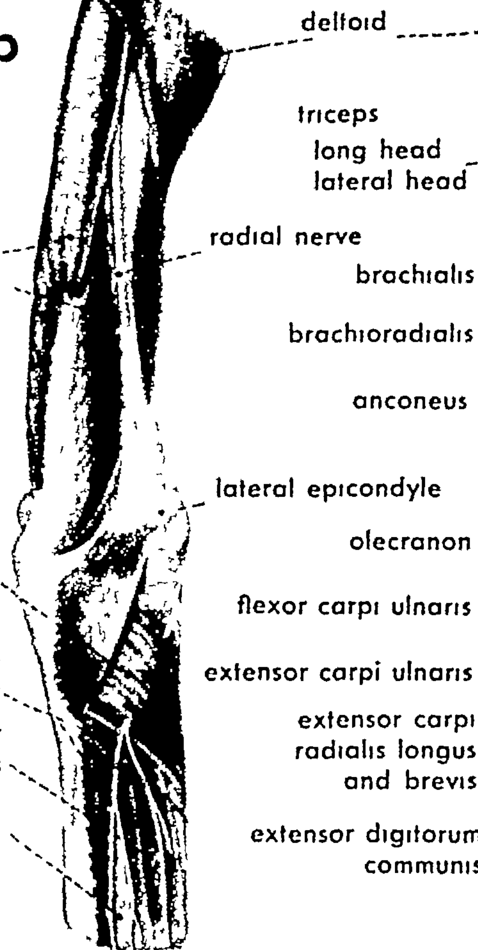
Superiorly, the capsular tear permitting the dislocation of the radial head can be seen by further reflection of the supinator and the common extensor origin This is best obtained by dissecting close to the capsule and the lateral epicondyle The one important structure to keep in mind is the radial nerve, and its position must be recognized at all stages of the dissection. Reduction of this fracture-dislocation is maintained by placing the forearm in the position of supination and flexion

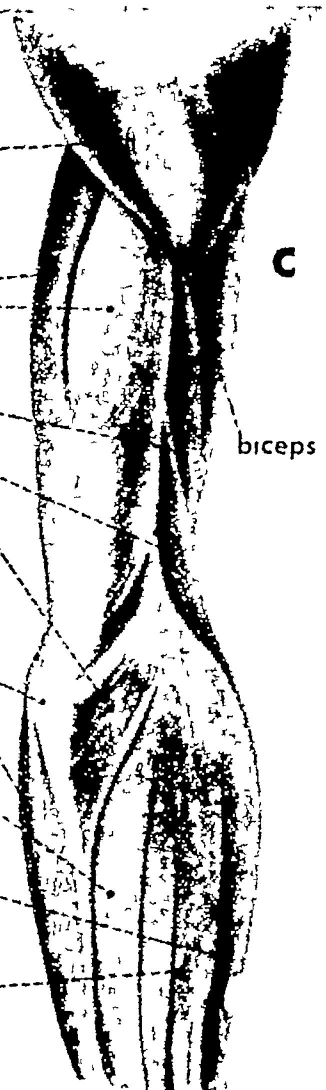
The exposure of a comminuted fracture of the radial head is shown in f, with a lateral incision depicted in d The incision is a short one in the lateral intermuscular plane Further dissection is direct to bone on the lateral epicondyle The common extensor origin is fused as one at the level of the radial head, but at operation a tendinous intersection can often be found, and the deeper incision follows this directly to the capsule of the joint The capsule is split longitudinally, exposing the joint easily By pronating and supinating the forearm, the radial head can be demonstrated Further, any articular fracture of the capitellar surface of the humerus is noted The lower end of the humerus can be studied further by capsular reflection anteriorly and posteriorly as required

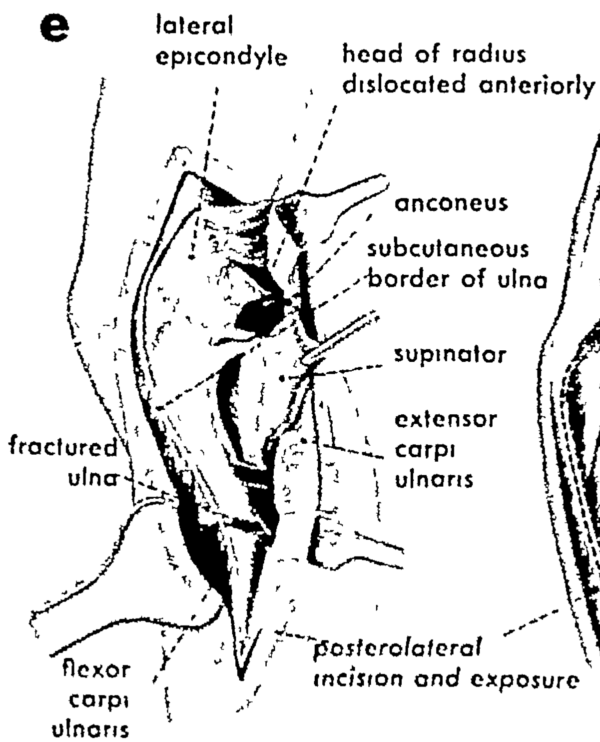
The lateral exposure of the radial head is much more easily performed and is preferred for routine uncomplicated fractures of the radial head and neck The one structure to recognize and to avoid injuring is the radial nerve

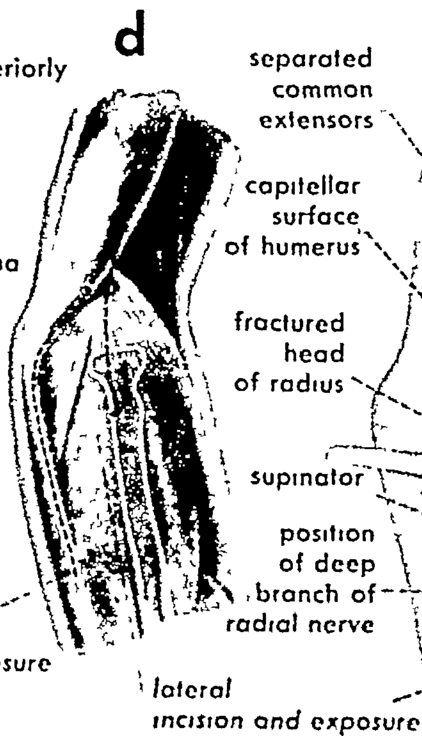
(Moseley, H F An Atlas of Surgical Exposures, North Chicago, Abbott)

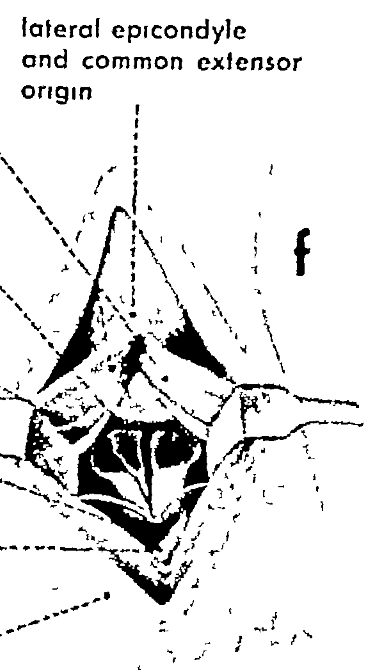

a
deltoid
brachialis
triceps
long head
medial head
brachioradialis
triceps
anconeus
supinator
extensor
carpi ulnaris
posterior interosseous
artery and nerve
abductor
pollicis longus
extensor
pollicis longus
pronator teres


b
radial nerve
lateral epicondyle


c
deltoid
triceps
long head
lateral head
brachialis
biceps
brachioradialis
anconeus
olecranon
flexor carpi ulnaris
extensor carpi ulnaris
extensor carpi
radialis longus
and brevis
extensor digitorum
communis


e
lateral
epicondyle
head of radius
dislocated anteriorly
anconeus
subcutaneous
border of ulna
supinator
extensor
carpi
ulnaris
fractured
ulna
flexor
carpi
ulnaris
posterolateral
incision and exposure


d
separated
common
extensors
capitellar
surface
of humerus
fractured
head
of radius
supinator
position
of deep
branch of
radial nerve
lateral
incision and exposure


f
lateral epicondyle
and common extensor
origin

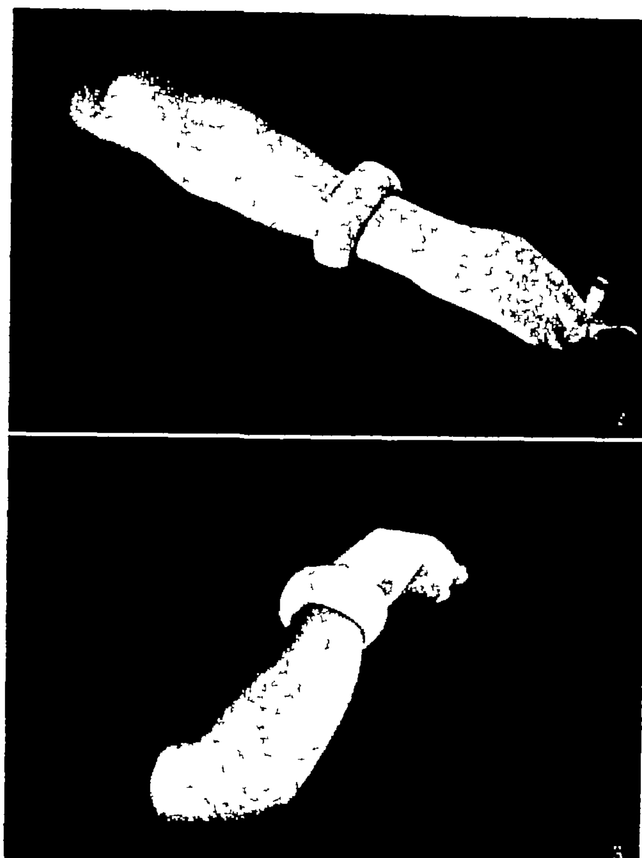


FIG 23 Posturing and draping for posterior, posterolateral and lateral exposures of the elbow

The posturing of the patient may be as in Figure 22, with the limb away from the side on an arm rest, or the surgeon may prefer the flexed position of the elbow with the limb manipulated into the desired position by the assistant's holding the wrist and the hand on the opposite side of the table By varying the degree of abduction at the shoulder, the field may include more and more of the posterior and the posteromedial aspects of the region

The steps in the draping are similar to those in Figure 22

(A) Posturing and draping completed with the elbow in extension

(B) Posturing and draping completed with the elbow in flexion

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3½ reels, 16 mm, sound color

Procurable from Central Office Film Library, Veterans Administration, Vermont Ave and H St, N W, Washington 25, D C

7
THE FOREARM

It is often difficult to reduce fractures of the shafts of both bones of the forearm in adults and to retain them in a position of adequate reduction by conservative means, such as closed manipulation and plaster casts Open operative reduction with internal fixation is probably the ideal method for the displaced fractures Malunion, cross-union and nonunion of such fractures are frequent complications of the closed treatment and necessitate exposure of the bones and secondary procedures such as freshening the bone ends and bone grafting Infective and neoplastic processes may also require exploration of the radius and the ulna

Exposure of the *radius* may be undertaken from the anterior or the posterior aspect In this connection, the "mobile extensor wad" stressed by Henry assists in our understanding of the anatomic relationships This "wad" consists of the brachioradialis and the extensors carpi radialis longus and brevis As illustrated in Figures 25 and 26, it can be grasped by the surgeon and moved from side to side The radius may be explored along either the anterior or the posterior boundary of these extensor muscles If the anterior exposure of the radius is required, the mobilization of this muscle mass is facilitated by ligation of the recurrent radial vessels which tether these muscles to the brachial vessels Once these are severed the mass can be dislocated laterally and the incision deepened If the posterior exposure of the radius is indicated, the incision is along the posterior boundary of the mass, and the main structure for preservation is the posterior interosseous nerve, detailed in Plates 29 and 30

The *ulna* is readily exposed posteriorly, as its posterior border is subcutaneous throughout Exposure of the median and the ulnar nerves is not covered separately in this series, but the anatomic relationships can be understood from the plates presented

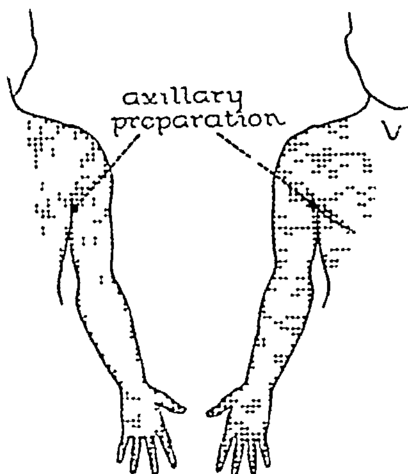


FIG 24 Area of skin preparation for operative procedures on the forearm

The area of skin preparation for operative procedures on the forearm is the same as for operative procedures on the elbow It is, however, more important to cleanse the hand and the fingers carefully Nails should be cut short and the cuticles softened and cleansed

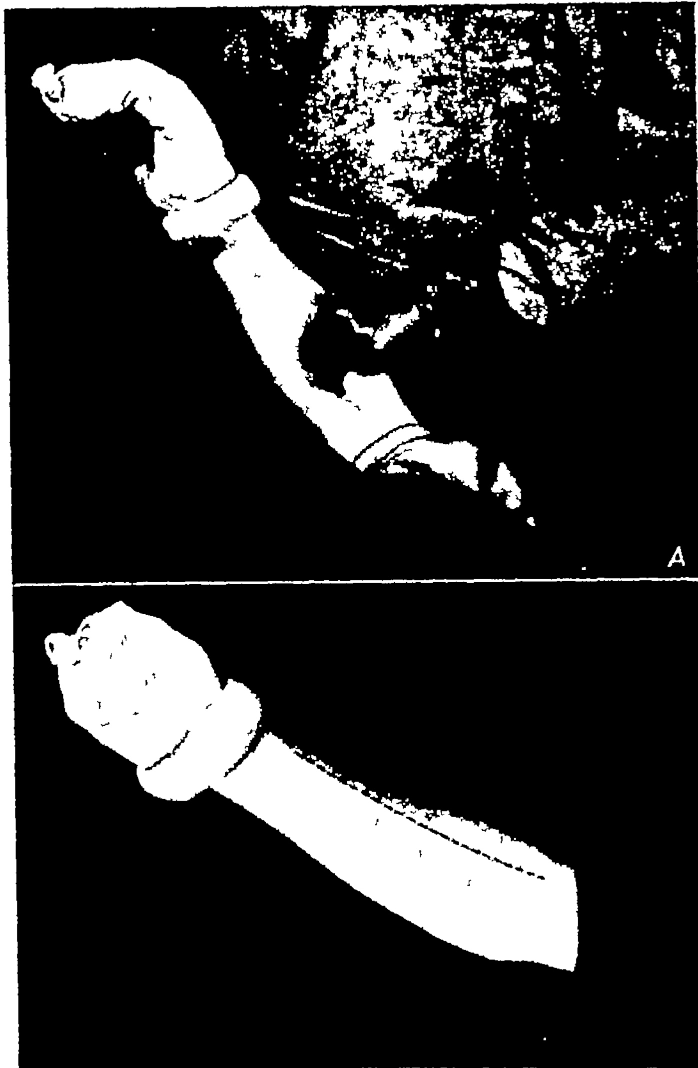


FIG 25 Posturing and draping for anterior exposure of the radius

This figure should be correlated with Figure 26 The limb is best arranged on the padded arm rest The draping is the same as that for procedures on the elbow, but if the hand has been meticulously prepared, a sterile rubber glove, or stockinet alone, may be used as a cover

(A) The surgeon is palpating the "mobile extensor wad" described by Henry to localize the line of his incision

(B) The posturing and the draping are complete The volar aspect of the forearm lies exposed on the draped arm rest The line of incision for the anterior exposure of the radius is drawn



FIG 26 Posturing and draping for posterior exposures of the radius and the ulna

The posturing illustrated in this instance is the same as for the elbow and the anterior aspect of the radius The forearm, however, will be in the position of pronation Some surgeons place the patient prone with the extensor aspect of the forearm uppermost on the arm rest, while others have the limb flexed across the trunk as previously described for the lateral and the posterolateral approaches to the elbow

The draping is the same as for procedures on the elbow and the anterior aspect of the radius A bloodless field may be arranged as required

(A) The surgeon indicates the posterior limit of the "extensor wad" The line of incision for the exposure of the radius will follow the posterior boundary of the long extensors

(B) The forearm is pronated and the lines of incision for the exposures of the ulna and the radius are shown.

PLATE 29

Anterior Exposure of the Radius

This plate illustrates the important anatomic structures and relations on the flexor aspect of the forearm

The ulna is most readily exposed from the posterior aspect, and many surgeons prefer the posterior exposure for the distal two thirds of the radius However, an anterior approach of the whole radial shaft is possible and is illustrated on this plate It is useful for exposing especially the upper third of this bone Access to the anterior aspect of the ulna, the ulnar artery and nerve, and also the median nerve centrally can be understood from a study of this series

Figure a shows the origins and the insertions of the deep muscles on the component bones The biceps tendon is inserted on the radial tuberosity and the supinator on the proximal portion of the radius The extensive origins of the flexor digitorum profundus and the flexor pollicis longus on the ulna and the radius, respectively, are seen Between the supinator and the flexor pollicis longus, the insertion of the pronator teres and the origin of part of the flexor digitorum sublimis are found The origin and the insertion of the pronator quadratus are shown distally Lying on the interosseous membrane are the anterior interosseous vessels and nerve

In b, these deep muscles are added, together with the important nerves and vessels The radial nerve divides into its superficial and deep branches on the upper part of the supinator The brachial artery, bounded laterally by the biceps tendon and medially by the median nerve, courses over the brachialis insertion and divides into its main tributaries, the radial and the ulnar arteries, which pass to the respective sides of the forearm to join the nerves of similar nomenclature

Figure c shows the addition of the flexor digitorum sublimis The complicated origin of this muscle from the humerus and the radius affords a protected entry into the forearm for the ulnar vessels, the median nerve and, medially, the ulnar nerve

In d, the remaining flexor muscles are added, and the courses of the radial artery and nerve in relation to the shaft of the radius are represented The brachioradialis and the extensor group are omitted for clarity, but they can be seen in e

The incision for exposure of the radius is shown in e This is a continuation of the anterolateral exposure of the humerus (Plate 24) and anterior exposure of the elbow and the radial head (Plate 26) It extends between the mobile extensor group formed by the brachioradialis and the extensors radialis longus and brevis on the radial side and the flexor carpi radialis on the ulnar side Care must be taken to avoid injury to the lateral cutaneous nerve of the forearm As the incision is deepened, the brachioradialis is retracted radially with the radial nerve, while the flexors are retracted ulnarward with the radial artery By fully pronating the forearm, the posterolateral surface of the radius is exposed This is the best surface of the distal half of the radius for application of a metallic plate, as it is devoid of muscular attachments Superiorly, the insertions of the pronator teres and the supinator are seen These may be reflected subperiosteally if exposure of the proximal shaft is required

(Moseley, H F An Atlas of Surgical Exposures, North Chicago, Abbott)

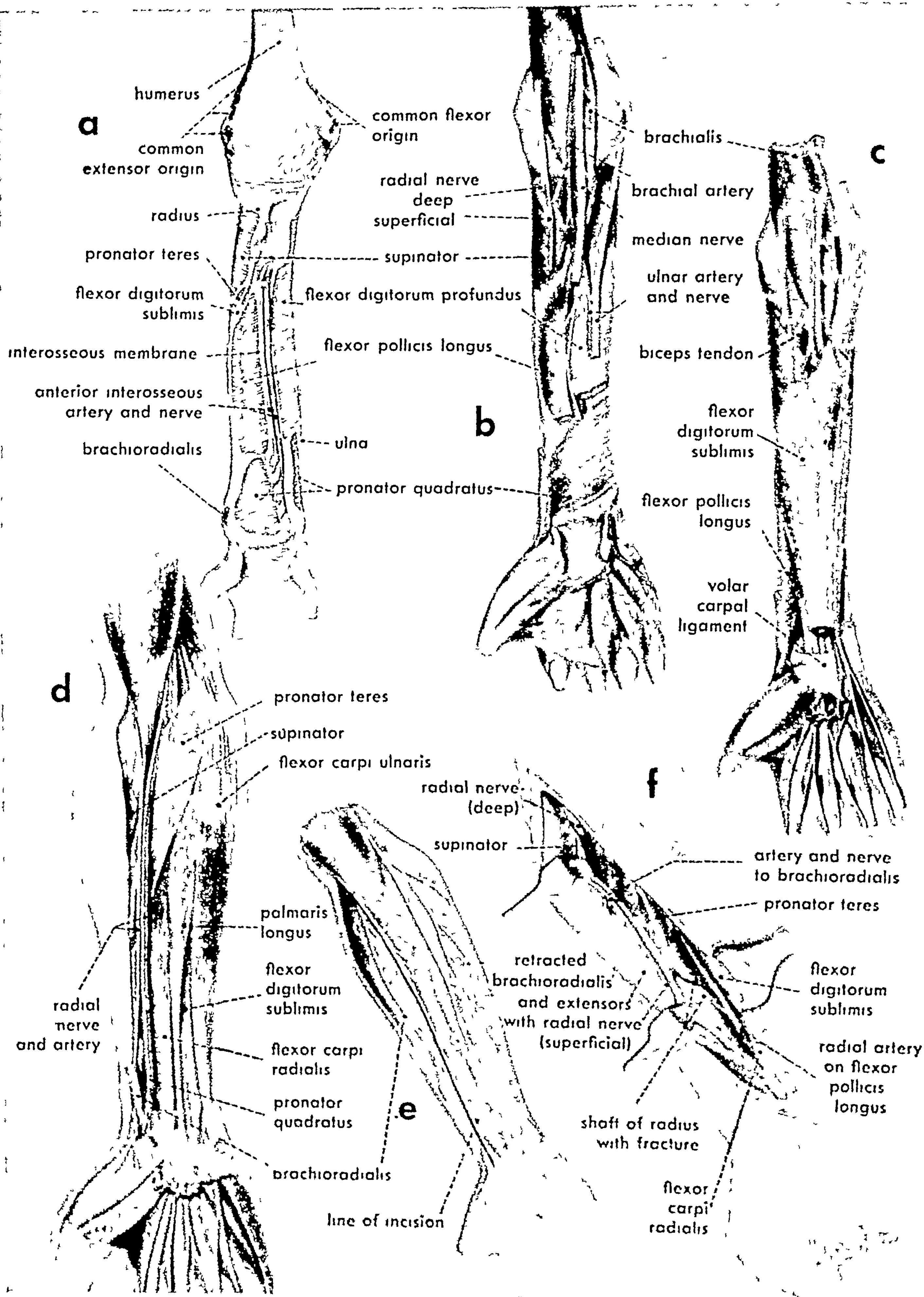

a
humerus
common extensor origin
common flexor origin
radius
pronator teres
supinator
flexor digitorum sublimis
flexor digitorum profundus
interosseous membrane
flexor pollicis longus
anterior interosseous artery and nerve
ulna
brachioradialis
pronator quadratus
b
brachialis
radial nerve deep superficial
brachial artery
median nerve
ulnar artery and nerve
c
biceps tendon
flexor digitorum sublimis
flexor pollicis longus
volar carpal ligament
d
pronator teres
supinator
flexor carpi ulnaris
palmaris longus
flexor digitorum sublimis
radial nerve and artery
flexor carpi radialis
pronator quadratus
brachioradialis
e
line of incision
f
radial nerve (deep)
supinator
artery and nerve to brachioradialis
pronator teres
retracted brachioradialis and extensors with radial nerve (superficial)
flexor digitorum sublimis
radial artery on flexor pollicis longus
shaft of radius with fracture
flexor carpi radialis

PLATE 30

Posterior Exposures of the Ulna and the Radius

Figures a, b and c illustrate the anatomic build-up on the extensor aspect of the forearm The important nervous structure from the point of view of surgical exposures is the dorsal interosseous nerve, which supplies the extensor musculature This nerve has previously been seen in its proximal course in Plates 24 and 26 It is seen here emerging from the supinator muscle, in which it has wound round the neck of the radius to reach its dorsal position It passes downward, supplying the extensor indicis, the extensors pollicis longus and brevis, and the abductor pollicis longus, as indicated in b The abductor pollicis longus and the extensor pollicis brevis pass obliquely across the extensors radialis longus and brevis in the lower third of the forearm Figure c shows the addition of the superficial extensors, in order from the radial side, the brachioradialis, the extensor digitorum communis, the extensor digiti quinti and the extensor carpi ulnaris

Figures d and e depict the incision and the exposure of the ulna The ulna is superficially placed, and the incision extends along its subcutaneous border and deeply, separates the aponeurosis and the periosteum binding the flexor and the extensor carpi ulnaris Both posterolateral and medial surfaces of the ulna can be quickly visualized after subperiosteal reflection of the soft tissues There is little danger of injury to either nerves or vessels in making this approach

Figures d and f show the incision and the exposure of the distal two thirds of the radius The incision is placed along the radial border of the extensor digitorum communis Depending on the area to be visualized, the shaft is exposed either above or below the extensor pollicis brevis and the abductor pollicis longus These muscles can then be retracted in the direction required When visualizing the radius distal to these obliquely directed muscles, care must be taken to avoid injury to the muscular branches of the dorsal interosseous nerve as the dissection is extended ulnarward

The posterior exposures illustrated on this plate are probably the most useful for fractures of both bones in the distal two thirds of the forearm

(Moseley, H F An Atlas of Surgical Exposures, North Chicago, Abbott)

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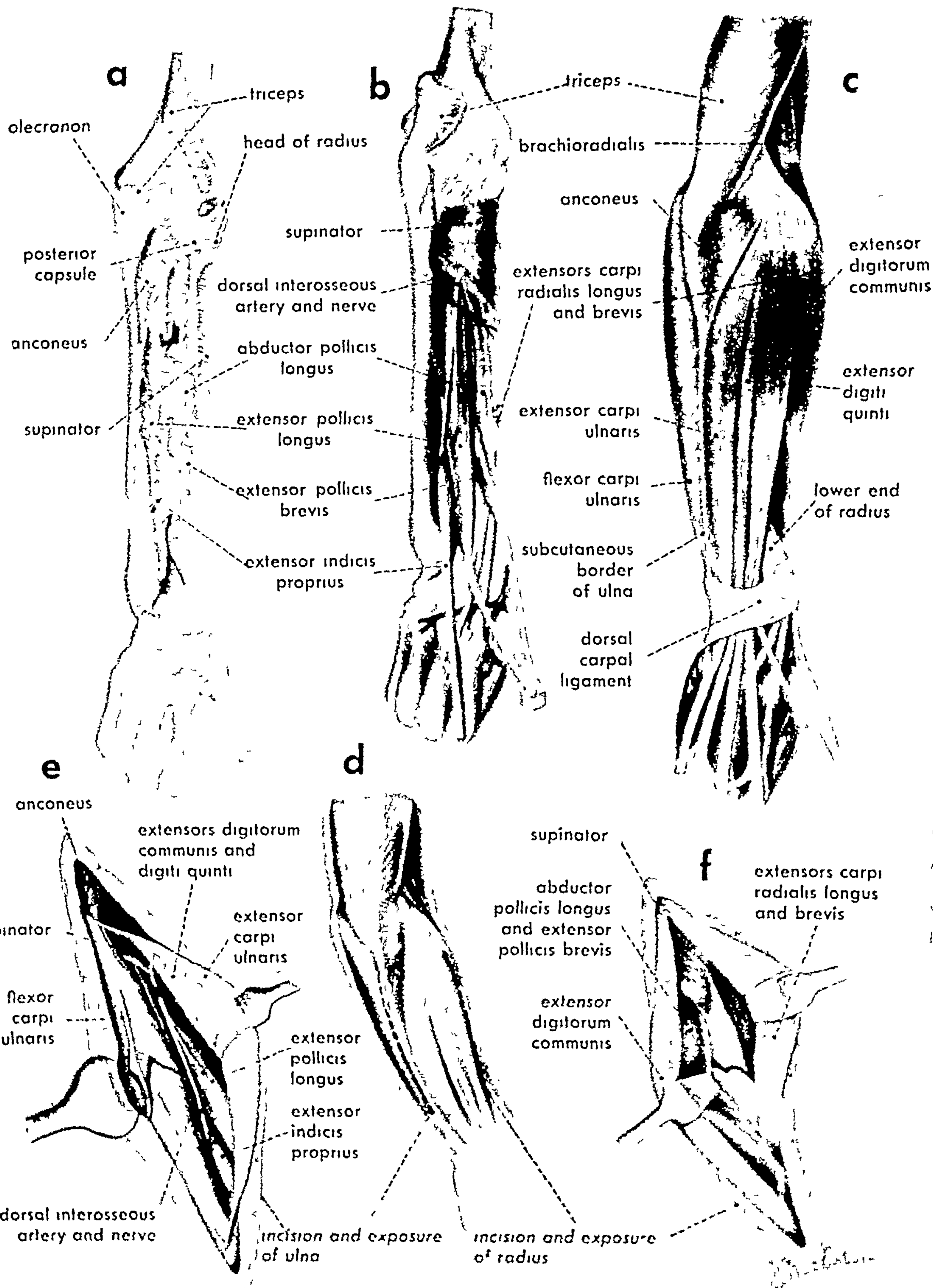
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3 reels, 16 mm, sound color

Procurable from Davis & Geck, Inc, 1 Casper St, Danbury, Conn



a
triceps
olecranon
head of radius
posterior capsule
anconeus
abductor pollicis longus
supinator
extensor pollicis longus
extensor pollicis brevis
extensor indicis proprius
b
triceps
supinator
dorsal interosseous artery and nerve
brachioradialis
extensors carpi radialis longus and brevis
c
anconeus
extensor digitorum communis
extensor digiti quinti
extensor carpi ulnaris
flexor carpi ulnaris
lower end of radius
subcutaneous border of ulna
dorsal carpal ligament
e
anconeus
extensors digitorum communis and digiti quinti
supinator
extensor carpi ulnaris
flexor carpi ulnaris
extensor pollicis longus
extensor indicis proprius
dorsal interosseous artery and nerve
incision and exposure of ulna
d
incision and exposure of radius
supinator
f
abductor pollicis longus and extensor pollicis brevis
extensors carpi radialis longus and brevis
extensor digitorum communis

8

THE WRIST

The *wrist joint* is composed of two mechanisms, the *radiocarpal* and the *inferior radio-ulnar joints* Both are subject to injury as well as degenerative and infective arthritis Fractures of the lower end of the radius take multiple forms and constitute one of the major groups of fractures involving the upper limb Fractures and dislocations frequently involve the proximal carpal bones, chiefly the navicular and the semilunar bones Derangements of the inferior radio-ulnar joint follow malunited fractures of the lower end of the radius Subluxations and dislocations of this joint of acute, recurrent and chronic types also occur Besides the lesions of the bones comprising the wrist joint, injuries and disease affect the tendons and their sheaths Cut tendons at wrist level and both traumatic and infective tenosynovitis may require operative exposure and treatment The major motor and sensory nerves, the median and the ulnar, may also suffer injury and require suture

Anteriorly, the radiocarpal joint is deeply placed at the bottom of the carpal tunnel (Plates 31 and 34) The landmarks, anteriorly, are the flexor carpi radialis, extending to the palpable tuberosity of the navicular on the radial side, and the flexor carpi ulnaris, inserting on the pisiform bone on the ulnar side Midway between these two tendons lies the palmaris longus, deep to which courses the median nerve, the most important structure for recognition in the anterior exposure The radial pulse can be palpated to the ulnar side of the tendon of flexor carpi radialis

On the radial side of the wrist, the styloid process of the radius is palpable in the anatomic snuff box, which is bounded anteriorly by the extensor pollicis brevis and posteriorly by extensor pollicis longus tendons

Dorsally, the prominence of Lister's tubercle on the lower end of the radius can be felt The extensor pollicis longus can be related to this landmark, round which it courses With the wrist in dorsiflexion, the hollow over the semilunar cornu can be determined This hollow is filled by the posterior cornu on volar flexion of the hand and is useful to localize this bone

On the ulnar side, the styloid process of the ulna is easily examined The inferior radio-ulnar

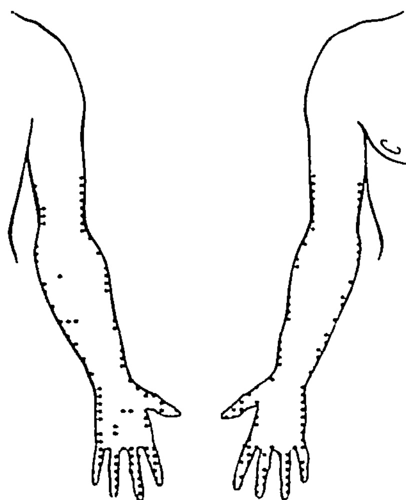


FIG 27 Area of skin preparation for operative procedures on the wrist

The area of skin preparation for operative procedures on the wrist should include the whole limb below the middle of the arm Meticulous attention must be devoted to the hand and the fingers Except in emergency, time should be taken to soften the palmar aspect of the hand and the areas round the nails The nails should be pared short and scrubbed to remove all gross dirt When indicated, the fingers may be covered with sterile finger cots A sterile plastic spray may be used to seal the fingers which cannot be cleansed adequately

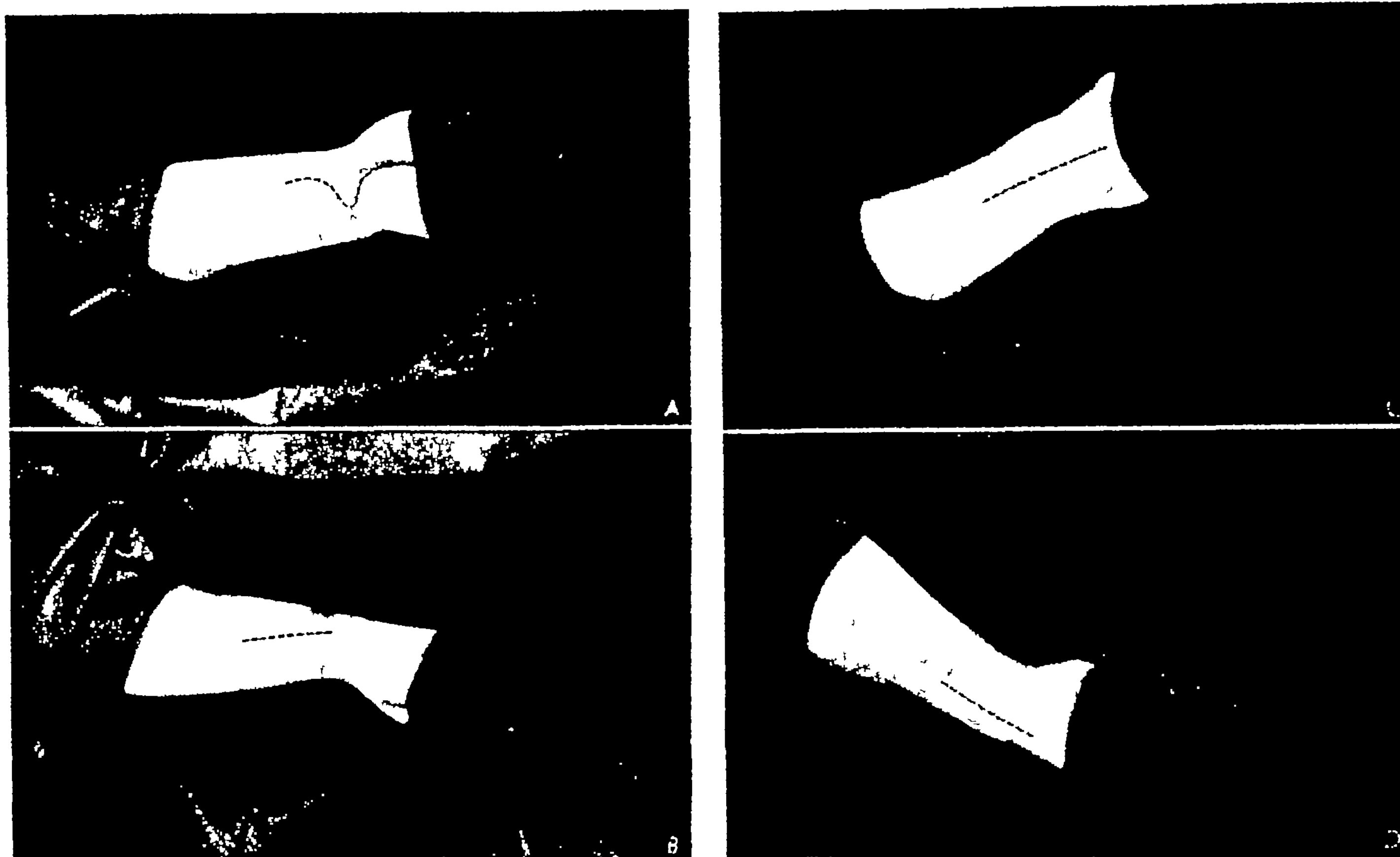


FIG 28 Posturing and draping for operative procedures on the wrist

The limb is best postured on a padded arm rest or table, and the surgeon and the assistants should be seated for the operation

The draping is similar to that for the elbow and the forearm, except that the hand and the fingers are covered by a sterile glove

Most operations are carried out in a bloodless field, secured through the use of the Esmarch bandage and a pneumatic tourniquet

(A) The field is arranged for the anterior exposure of the wrist The line of incision is indicated

(B) The subject holds his hand with its ulnar border toward the surgeon The forearm is pronated The incision for exposure of the lower end of the ulna is shown

(C) The forearm is in the position of pronation The incision for the posterior exposure of the wrist joint is illustrated

(D) The forearm is almost completely supinated The radial aspect of the wrist is toward the surgeon The incision for exposure of the inferior radio-ulnar joint is depicted

joint can be located by digital examination especially when the forearm is rotated

The joints are most accessible on the dorsal, the radial and the ulnar aspects Operative exposures and procedures from these aspects are illustrated in this section Some disorders such as anterior dislocation of the semilunar are accessible only by an anterior exposure The relationships for understanding this approach are also covered in this series

PLATE 31

Anterior Exposure of the Wrist Joint

The carpal tunnel is the traffic bottleneck for all the important structures passing between the forearm and the palm of hand These structures are the tendons, the nerves and the blood vessels illustrated in Figures a, b and c The venous and the lymphatic channels are omitted for simplicity

In a, the skeletal framework is shown with the tendons severed at the level of the pronator quadratus The radial artery, however, is shown in continuity as it courses through the first interosseous interspace to form the deep palmar arch with the communicating branch of the ulnar artery The posterior, the radial and the ulnar walls of the carpal tunnel are seen The posterior wall, a smooth continuous surface, is formed by the ligamentous and fascial tissue overlying the radiocarpal and the carpal joints This wall is prolonged proximally into the forearm on the anterior margins of the radius and the ulna and the fascia overlying the pronator quadratus The radial wall is bounded by the tuberosity of the scaphoid and by the greater multangular bones, while the ulnar boundary is formed by the pisiform and the uncinate process with their ligamentous attachments

Figure b shows the completion of the flexor digitorum profundus, the flexors carpi radialis and ulnaris, and the flexor pollicis longus The tendons of the flexor carpi radialis and the flexor carpi ulnaris constitute the lateral and the medial boundaries on the anterior aspect proximal to the carpal tunnel The median and the ulnar nerves are the most important structures in the anterior exposure of the wrist The median nerve runs between the planes of the flexor digitorum profundus and sublimis and lies just deep to the plane of the flexor carpi radialis and the palmaris longus The ulnar nerve lies on the ulnar side of the ulnar artery and is superficially placed at wrist level between the flexor carpi ulnaris and the common flexor tendon mass

In Figure c, the position of the palmaris longus and its continuity into the palmar fascia is indicated by dotted lines This overlies the volar carpal ligament, which forms the anterior wall of the carpal tunnel and binds the scaphoid tuberosity and the greater multangular bones radially with the pisiform and the uncinate process on the ulnar side

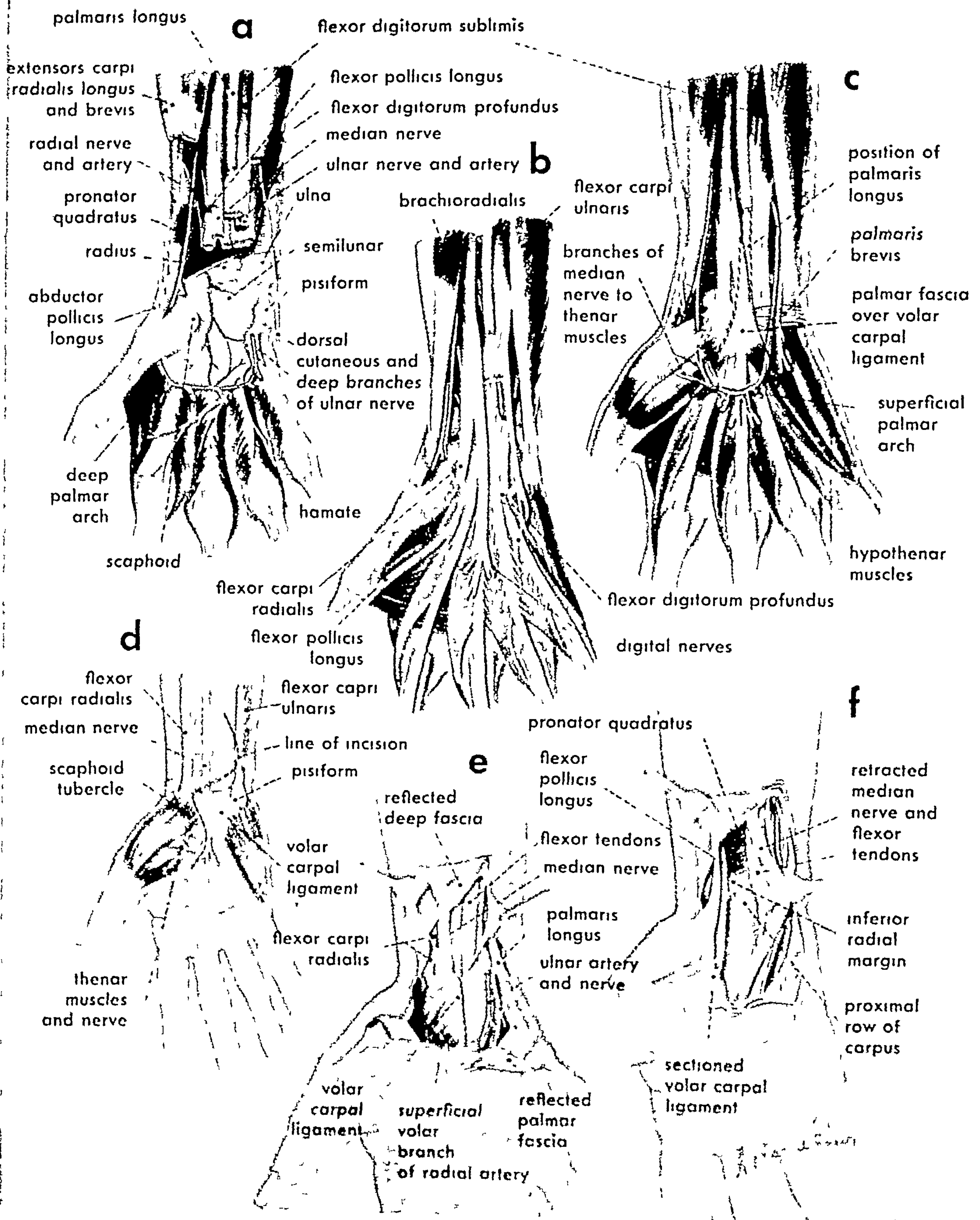
The thenar musculature is represented, together with the important motor branches from the median nerve These are endangered by incisions extending into the palm They must be visualized and preserved Figure c also shows the completion of the superficial palmar arch of vessels and the addition of the flexor digitorum sublimis tendons, the hypothenar muscles and the palmaris brevis

The anatomic relations depicted in Figures a, b and c enable us to understand the standard anterior exposure of the radiocarpal articulation illustrated in Figures d, e and f

As the line of incision traverses the skin creases, an S-shaped incision is preferred to a linear one The relation of the distal portion of this line of section to the branches of the median nerve which supply the thenar muscles must again be mentioned to stress its importance The parent median nerve, however, is the structure of greatest significance, and it is best to isolate the nerve trunk immediately after division of the deep fascia overlying the common tendon mass just above the volar carpal ligament (Fig e) As stated above, the nerve lies just beneath the plane of the flexor carpi radialis and is found by dissecting between this tendon and that of the palmaris longus Once the nerve has been seen and isolated, the volar carpal ligament can be severed by incising on to a grooved director After reflection of the palmar fascia and section of the carpal ligament, the common flexor tendons and the median nerve are carefully retracted ulnarward from the tendons of the flexor carpi radialis and the flexor pollicis longus, which remain in the radial concavity of the carpal tunnel The smooth posterior wall of the tunnel can now be seen, as in Figure f When present, dislocations of the semilunar bone, with or without the whole or the ulnar part of the scaphoid, can be reduced under direct vision, or these carpal bones can be excised as required

The tuberosity of the scaphoid can be readily exposed by a short transverse incision centered directly over its bony prominence Through this approach the operative procedures for fixation by screw, drilling or bone grafting fresh and ununited fractures of the scaphoid can be carried out with the assistance of radiologic control

(Moseley, H F An Atlas of Surgical Exposures, North Chicago, Abbott)



a
palmaris longus
flexor digitorum sublimis
extensors carpi radialis longus and brevis
flexor pollicis longus
flexor digitorum profundus
median nerve
radial nerve and artery
ulnar nerve and artery
pronator quadratus
ulna
radius
semilunar
pisiform
abductor pollicis longus
dorsal cutaneous and deep branches of ulnar nerve
deep palmar arch
hamate
scaphoid
b
brachioradialis
flexor carpi ulnaris
flexor carpi radialis
flexor pollicis longus
flexor digitorum profundus
digital nerves
c
position of palmaris longus
branches of median nerve to thenar muscles
palmaris brevis
palmar fascia over volar carpal ligament
superficial palmar arch
hypothenar muscles
d
flexor carpi radialis
flexor capri ulnaris
median nerve
line of incision
scaphoid tubercle
pisiform
volar carpal ligament
flexor carpi radialis
thenar muscles and nerve
e
reflected deep fascia
flexor tendons
median nerve
palmaris longus
ulnar artery and nerve
volar carpal ligament
superficial volar branch of radial artery
reflected palmar fascia
f
pronator quadratus
flexor pollicis longus
retracted median nerve and flexor tendons
inferior radial margin
proximal row of carpus
sectioned volar carpal ligament

Plate 32

Posterior Exposures of the Wrist Joint

Posterior exposures in the region of the wrist are required for arthrodesis of this joint, plastic repairs in subluxations and dislocations of the radio-ulnar joint, and excision of the lower end of the ulna for derangements of the radio-ulnar joint, most frequently following malunion of Colles' fracture

The dorsal aspect of the wrist is much less complicated than its anterior counterpart Figures a, b and c illustrate the important relationships of the tendons in this area

In Figure a, the dorsal carpal arch is formed by the anastomosis of the terminal branches of the dorsal interosseous artery with the dorsal carpal branch of the radial artery The tendons are sectioned above wrist level, but the stubs of their insertions are shown The most important are the extensors carpi radialis longus and brevis and the extensor carpi ulnaris

Figure b shows these tendons in continuity with the addition of the extensor pollicis longus, which hooks round Lister's tubercle on the lower end of the radius, and the extensor indicis proprius, which crosses the lower end of the radius deep to the extensor digitorum communis

Figure c shows the group of tendons completed with the extensor digitorum communis and the extensor digiti quinti The dorsal carpal ligament binds the tendons to the posterior surfaces of the radius and the ulna to prevent webbing on movement Separate fascial and synovial compartments retain the tendons under the carpal ligament These compartments are from the radial to the ulnar side for abductor pollicis longus and extensor pollicis brevis, extensors carpi radialis longus and brevis, extensor pollicis longus, extensor digitorum communis and extensor indicis proprius, extensor digiti quinti and, finally, for extensor carpi ulnaris These sheaths must frequently be opened in the various exposures to mobilize the tendons sufficiently for retraction

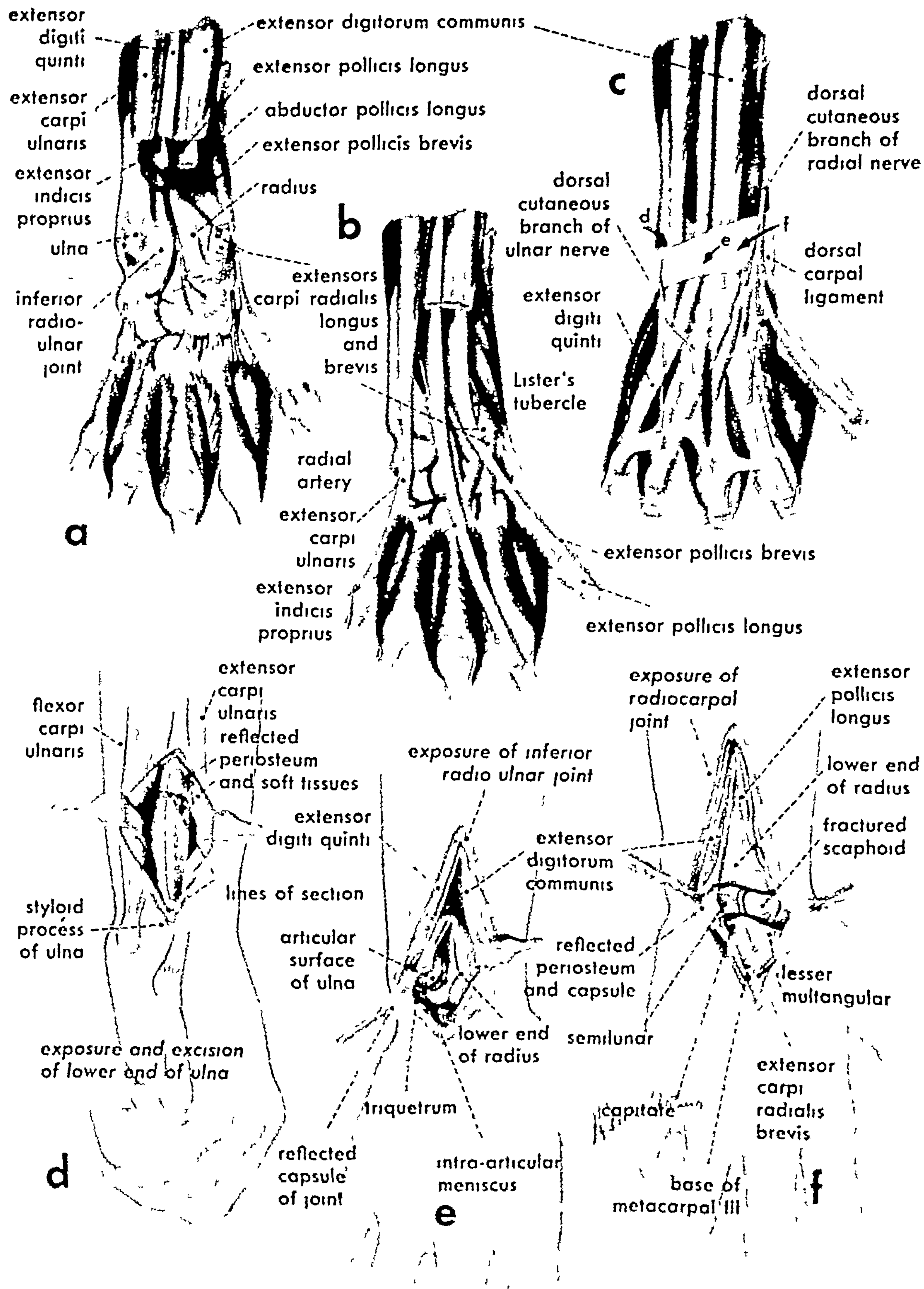
The terminal branches of the radial nerve and the dorsal branches of the ulnar nerve course over this ligament to supply the dorsal skin of the hand and the fingers

Figure d illustrates the exposure of the lower end of the ulna through a short longitudinal incision along the ulnar border of the forearm proximal to joint level The incision, when deepened, passes between the flexor and the extensor carpi ulnaris directly to the bone The periosteum is incised and reflected with the soft tissues from the circumference of the bone The ulna is transected as indicated by the dotted line, the cut end is drawn outward and removed by section of the styloid process A periosteal cuff, the styloid process, and the intra-articular meniscus remain to maintain the stability of the wrist joint on the ulnar side The dorsal branch of the ulnar nerve can sometimes be seen, but it is not endangered in this exposure

The inferior radio-ulnar joint is approached by a longitudinal incision through the skin and the subcutaneous tissues, as indicated in Figure e The sheath of extensor digiti quinti is opened and the tendon is retracted ulnarward The sheath of the extensor digitorum communis is reflected with the periosteum to expose the adjacent area of the radius The joint and the intra-articular meniscus can be examined, if required, by opening the joint capsule Ligamentous reconstruction with fascia can be performed when indicated

Figure f illustrates the exposure for arthrodesis of the radiocarpal joint It is unnecessary to employ the S-shaped incision when crossing the flexor creases unless the operation is to be followed by mobility of the wrist, as occurs when bones of the proximal row of the carpus are removed through this approach The incision is centered on the arrow f in Figure c, just radial to the extensor digitorum communis The sheath of extensors digitorum communis and indicis proprius is then reflected ulnarward with the periosteum The periosteum is also reflected from the radius toward the radial side and carries with it the extensor pollicis longus from its groove The ligaments and the capsules are dissected from the carpus as required Gentle retraction will afford adequate exposure of the dorsal surface of the lower end of the radius and of the carpus In this drawing, an ununited fracture of the scaphoid is illustrated, and arthrodesis is indicated if traumatic arthritis develops

(Moseley, H F An Atlas of Surgical Exposures, North Chicago, Abbott)



extensor digiti quinti
extensor digitorum communis
extensor pollicis longus
extensor carpi ulnaris
abductor pollicis longus
extensor pollicis brevis
extensor indicis proprius
radius
ulna
inferior radio-ulnar joint
a
b
extensors carpi radialis longus and brevis
radial artery
extensor carpi ulnaris
extensor indicis proprius
Lister's tubercle
extensor pollicis brevis
extensor pollicis longus
c
dorsal cutaneous branch of radial nerve
dorsal cutaneous branch of ulnar nerve
d
e
f
dorsal carpal ligament
extensor digiti quinti
flexor carpi ulnaris
extensor carpi ulnaris
reflected periosteum and soft tissues
lines of section
styloid process of ulna
exposure and excision of lower end of ulna
d
exposure of inferior radio ulnar joint
extensor digiti quinti
extensor digitorum communis
articular surface of ulna
reflected periosteum and capsule
lower end of radius
triquetrum
reflected capsule of joint
intra-articular meniscus
e
exposure of radiocarpal joint
extensor pollicis longus
lower end of radius
fractured scaphoid
lesser multangular
semilunar
capitate
extensor carpi radialis brevis
base of metacarpal III
f

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Film: Surgical Approaches to Joints of the Wrist (by using animated diagrams and actual dissection, approaches to the joints of the wrist are shown) (1951) (By LeRoy C Abbott, M D, Robert D Ray, M D, Paul A Gregorieff, M D, Philip D Wilson, Jr, M D, and J B de C M Saunders, M B, San Francisco)

3 reels, 16 mm, sound color

Procurable from Central Office Film Library, Veterans Administration, Vermont Ave and H St, N W, Washington 25, D C

9
THE HAND

The supremacy of man over animal is due largely to the evolution of the *hand* as a mechanism for grasp The amazing capacity of the hand to carry out the infinite variety of works directed by the human mind has been a source of wonder to thinking men throughout the ages In no published work is this more keenly sensed than in the Bridgewater treatise "The Hand, Its Mechanism and Vital Endowments as Evincing Design" written in 1833 The Earl of Bridgewater had left funds for the writing, the printing and the publishing of eight treatises "On the Power Wisdom and Goodness of God, as manifested in the creation, illustrating such work by all reasonable arguments, as for instance the variety and formation of God's creatures in the animal, vegetable, and mineral kingdoms, the effect of digestion and thereby of conversion, the *construction of the hand of man,* and an infinite variety of other arguments, as also by discoveries ancient and modern in arts, sciences and the whole extent of literature ' Sir Charles Bell, one of the great medical minds of his day, was given the task to write on the hand and its anatomic construction, and it was illustrated from the point of view of comparative morphology In our own time, Professor Wood-Jones has approached the same subject from the functional point of view and his work "The Principles of Anatomy as Seen in the Hand," should form part of the compulsory reading in our medical curriculum Surgeons also have devoted their lives to the clinical disorders of the hand Before the chemotherapeutic era, the greatest time loss in industry and the most crippling functional derangements resulted from infected wounds of the hand Dr Kanavel who was interested in the industrial worker recognized this problem and made it a life study His work, describing the fascial spaces which bear his name, is published in the monograph "Infections of the Hand " His school of thought has been continued by Doctors Koch Mason and Allen, who have made important contributions to the surgical literature on the many associated problems World War II brought into being the Hand Centers for the American Casualties, under the direction of Dr Bunnell With able organization and direction, a vast number of crippled hands were reconstructed and some standardization of treatment was attained This work is represented in Dr Bunnell's textbook "Surgery of the Hand" and in the American Society for the Surgery of the Hand These two great forces have exerted a powerful influence in raising the standards of treatment of hand disorders throughout the world Many others have contributed to this great work, and the complexity of the anatomic structure and the intricate functional capacity of the hand are inciting surgeons in increasing numbers to obtain more exact knowledge and greater technical skill in dealing with the many lesions to which this part is prone

PLATE 33

Anterior Relations of the Wrist and the Hand

The first two plates of this series illustrate the *anatomic structures from the anterior aspect*

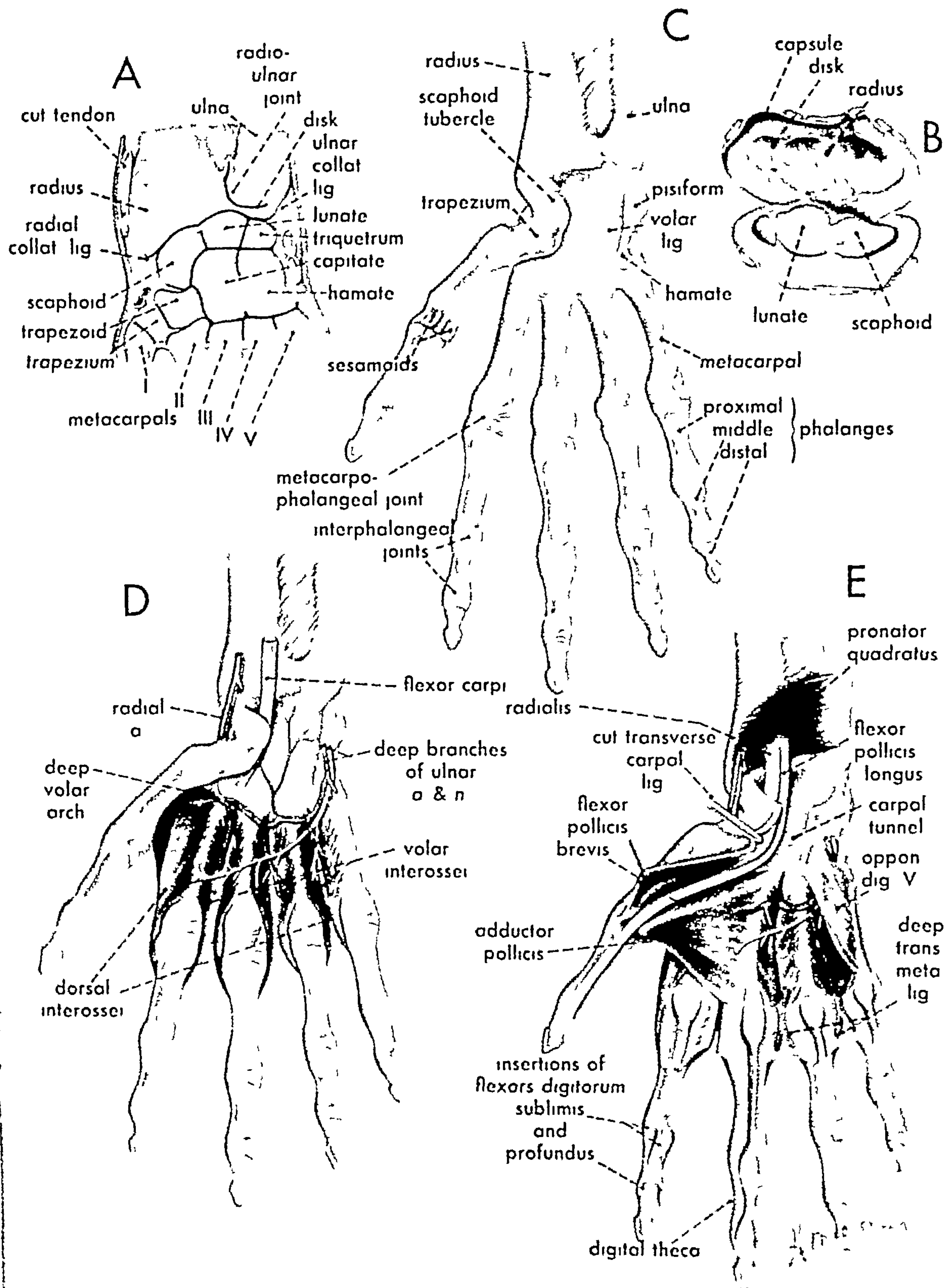
Figure A is a coronal section of the inferior radio-ulnar, the radiocarpal, the carpal and the carpo-metacarpal joints and the component bones The nomenclature of the carpal bones is given

Figure B shows the radiocarpal joint hinged open by section of the capsule and the tendons posteriorly and on each side The lower end of the radius and the intra-articular disk form a smooth surface continuous with the capsule This surface is largely concave, whereas inferiorly a continuous convex opposing surface is formed by the scaphoid, the lunate and the triquetrum bones

The anterior aspect of the skeletal framework with the joint capsules and interosseous membrane is shown in C Note the two sesamoid bones in the capsule of the metacarpophalangeal joint of the thumb The variable sesamoid bones related to the corresponding joints of the other digits are omitted

In D, the deepest layer of the musculature formed by the dorsal and the volar interosseous muscles is added Their tendons of insertion are shown passing dorsally to enter the extensor expansion The insertion of the tendon of flexor carpi radialis into the base of the index metacarpal is seen as one of the relations of the radial aspect of the carpal tunnel The deep volar arch is formed by the radial artery entering the palm through the first interosseous space to join the deep branch of the ulnar artery Special attention should be given to the deep branch of the ulnar nerve, which carries the motor supply to the interossei and part of the lumbricals

Figure E shows the addition of the adductor and the flexor pollicis brevis muscles This latter muscle consists of two parts which form the groove for the tendon of flexor pollicis longus The opponens digiti quinti composes the deep layer of the hypothenar muscles The pronator quadratus muscle covered by its fascia gives a smooth surface on the lower end of the radius and the ulna, grading into the posterior wall of the carpal tunnel The insertions of the flexor tendons and the arrangement of the thecal canals and the transverse metacarpal ligaments are diagrammatically represented On the index finger the stump of insertion of the profundus tendon on the base of the terminal phalanx and the adjacent capsule can be seen The two insertions of the flexor sublimis on the sides of the middle phalanx should also be noted The theca on the index, the ring and the little fingers is opened to show its canal and the related transverse metacarpal ligaments It is sectioned near the middle of the proximal phalanx, but it is shown open and complete in its extent for the middle finger



A
cut tendon
radius
radial
collat lig
scaphoid
trapezoid
trapezium
radio-
ulnar
joint
ulna
disk
ulnar
collat
lig
lunate
triquetrum
capitate
hamate
I
II
III
IV
V
metacarpals
C
radius
scaphoid
tubercle
trapezium
ulna
pisiform
volar
lig
hamate
sesamoids
metacarpal
proximal
middle
distal
phalanges
metacarpo-
phalangeal joint
interphalangeal
joints
capsule
disk
radius
B
lunate
scaphoid
D
radial
a
deep
volar
arch
flexor carpi
deep branches
of ulnar
a & n
volar
interossei
dorsal
interossei
E
radialis
pronator
quadratus
cut transverse
carpal
lig
flexor
pollicis
longus
flexor
pollicis
brevis
carpal
tunnel
oppon
dig V
adductor
pollicis
deep
trans
meta
lig
insertions of
flexors digitorum
sublimis
and
profundus
digital theca

Plate 34

Anterior Relations of the Wrist and the Hand

This plate completes the anatomic build-up from the anterior aspect and, in addition, shows the relations in cross sections at the levels of the inferior radio-ulnar joint and the carpal tunnel

The tendons of flexor digitorum profundus are added in A and are shown extending to the proximal part of the thecal tunnel The thecal tunnels are completed for the thumb and for the index and the middle fingers, but in these latter they are opened throughout their extent The four lumbrical muscles arise in the palm from the profundus tendons and course round the radial side of each digit to insert into the dorsal tendinous expansion The opponens pollicis is added and the hypothenar musculature is completed with flexor and abductor digiti quinti

Figure B illustrates the addition of the flexor digitorum sublimis Details of its insertions are shown on the ring finger, and again on the middle finger, where the profundus tendon is also present The little finger details the thecal arrangement, and this is further depicted in the index finger with the relation to the digital vessels and nerves The musculature of the thenar eminence is completed with the addition of abductor pollicis brevis The site of entrance of the motor branches of the median nerve to this group of muscles is shown in both A and B These branches are endangered by incisions in the palm, and the location of entrance, which is a thumb's breadth from the scaphoid tuberosity, should always be kept in mind

The transverse carpal ligament completes the carpal flexor tunnel The median nerve runs deep to this ligament, and its digital branches to the thumb, the index, the middle and the radial half of the ring fingers are shown The remaining sensory digital supply is from the superficial branch of the ulnar nerve The superficial volar arterial arch with its digital branches can be seen in relation to the sensory nerve supply

The volar carpal ligament, the palmaris longus, palmar fascia, and deep fascia over the thenar and the hypothenar muscles are added in C The palmaris longus developmentally is the remains of the most superficial flexor mechanism extending into the palmar fascia and into each finger Fibers connect it closely with the skin of the palm and of the proximal flexor surface of each finger These fibrous connections are well seen clinically in cases of advanced Dupuytren's contracture

The cross section D is made at the level of the inferior radio-ulnar joint It shows well the transverse course of the pronator quadratus muscle

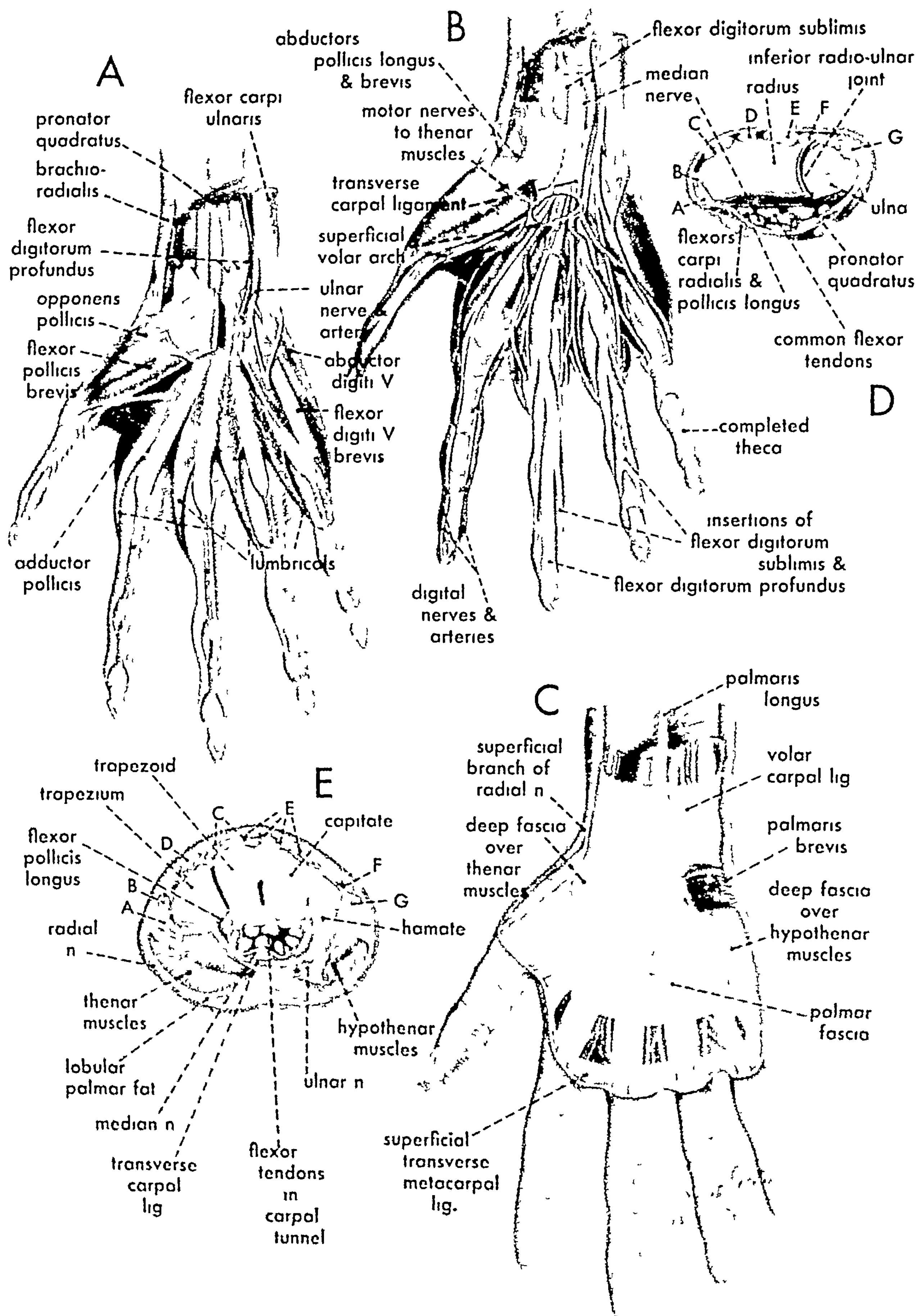
The extensor tendons are indicated by letters which are represented as follows (a) abductor pollicis longus, (b) extensor pollicis brevis, (c) extensors carpi radialis longus and brevis, (d) extensor pollicis longus, (e) extensors digitorum communis and indicis proprius, (f) extensor digiti quinti, and (g) extensor carpi ulnaris

The flexor tendons to the fingers and the thumb, together with the median nerve, lie deep to the volar carpal ligament Their deep surface rests on the fascia overlying the pronator quadratus In this situation the potential fascial space of the forearm (Parona's space) exists and is continuous with the middle palmar space (Kanavel's space)

Figure E depicts a cross section through the carpal tunnel, in which the flexor tendons and the median nerve are seen The relation of the transverse carpal and the volar carpal ligaments to the tunnel and to the thenar and the hypothenar musculature should be studied

There has been some rearrangement of the extensor tendons when compared with Figure D, in that the extensor pollicis longus has moved radial to the extensors carpi radialis longus and brevis

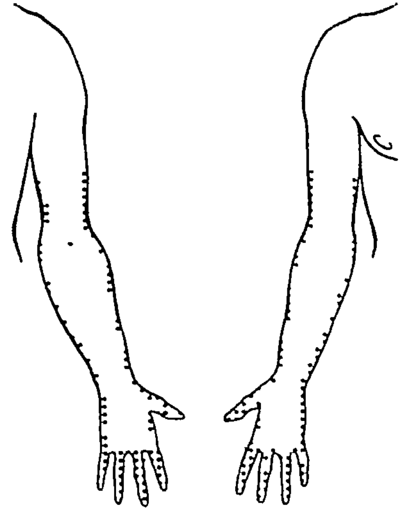
The figures on this plate complete the build-up of structures on the anterior aspect

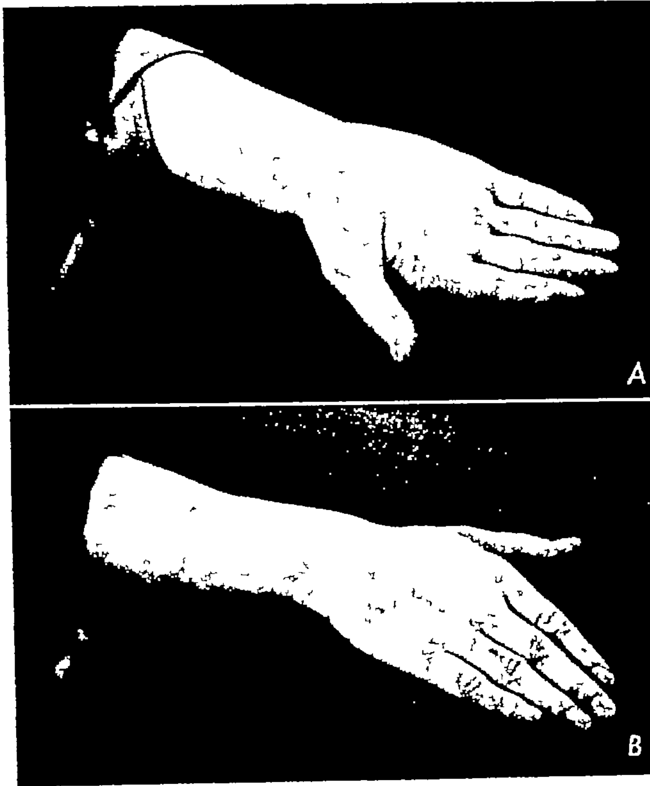


A
flexor carpi ulnaris
pronator quadratus
brachio-radialis
flexor digitorum profundus
opponens pollicis
flexor pollicis brevis
ulnar nerve & artery
abductor digiti V
flexor digiti V brevis
adductor pollicis
lumbricals
B
abductors pollicis longus & brevis
motor nerves to thenar muscles
transverse carpal ligament
superficial volar arch
flexor digitorum sublimis
median nerve
completed theca
insertions of flexor digitorum sublimis &
flexor digitorum profundus
digital nerves & arteries
D
inferior radio-ulnar joint
radius
A
B
C
D
E
F
G
ulna
flexors carpi radialis & pollicis longus
pronator quadratus
common flexor tendons
E
trapezoid
trapezium
flexor pollicis longus
capitate
hamate
radial n
thenar muscles
lobular palmar fat
median n
transverse carpal lig
flexor tendons in carpal tunnel
ulnar n
hypothenar muscles
C
palmaris longus
superficial branch of radial n
volar carpal lig
deep fascia over thenar muscles
palmaris brevis
deep fascia over hypothenar muscles
palmar fascia
superficial transverse metacarpal lig.

FIG 29 Area of skin preparation for operative procedures on the hand

The area covered is the same as for the forearm and the wrist The initial shaving, paring of nails and mechanical scrubbing should be carried out carefully in the ward In the operating room, a ten-minute scrub with green soap or one of the detergents, followed by washing with saline, should be performed before the antiseptic solution is applied





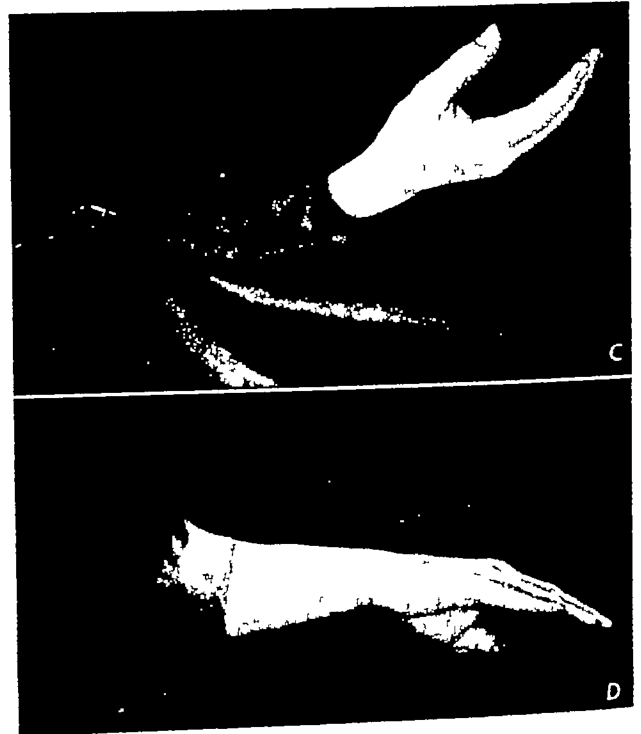


FIG 30 Posturing and draping for operative procedures on the hand and the fingers

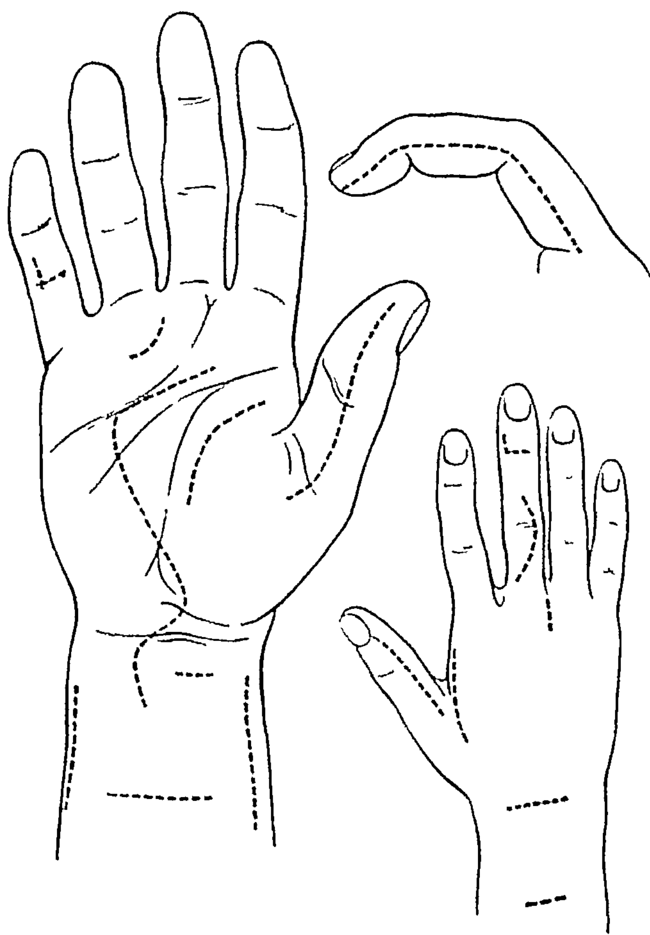
The posturing and the draping are the same as for the wrist, except that the hand and the fingers remain uncovered Depending on the area required, the fingers may be covered by sterile finger cots, or they may be sprayed with sterile plastic Some procedures permit the covering of the hand with stockinet and operating through an opening therein Most operative procedures on the hand are best performed in a bloodless field

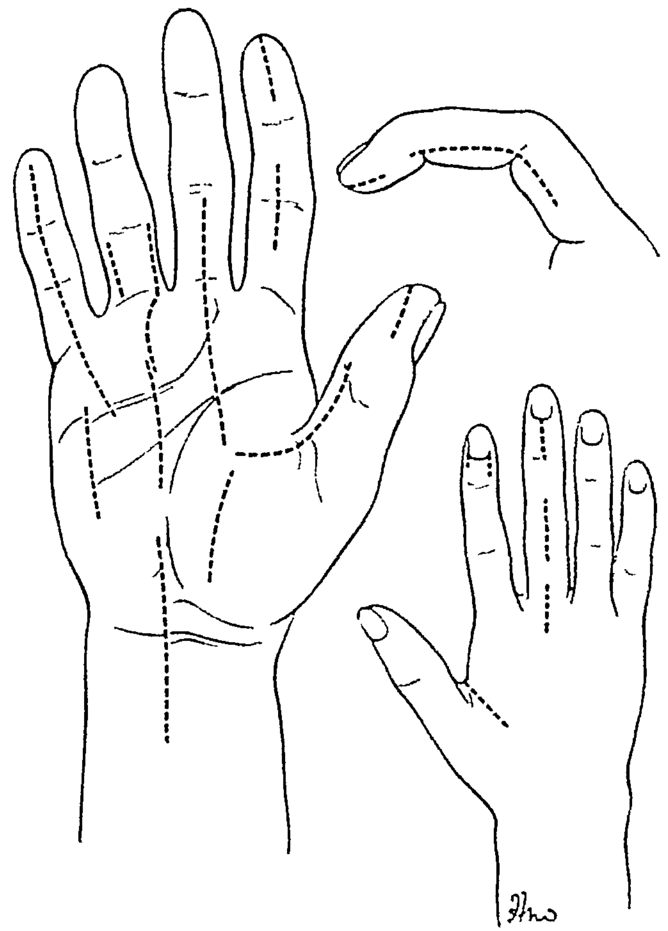
(A) The posturing and the draping are completed with the volar aspect of the wrist and the fingers available for surgery

(B) The dorsal aspect of the wrist, the hand and the fingers is arranged as the field of operation

(C) The subject holds the radial aspect of the wrist, the thumb and the index finger toward the surgeon

(D) The ulnar aspect of the wrist, the hand and the small finger is arranged for the surgeon





lines of incision

FIG 31 The correct and the incorrect lines of incision for operative procedures on the hand and the fingers (Moseley, H F, Ed Textbook of Surgery, St Louis Mosby)

PLATE 35

Clinical Applications of the Volar Anatomy

Figure A represents the *flexion creases* in their relation to the underlying bones and joints This has been taken from a roentgenogram, where the creases are marked with a radiopaque medium

The *synovial sheaths* of the flexor tendons are shown in B It will be noted that the digital sheath of the little finger is continuous with the ulnar bursa, whereas the sheaths of the index, the long and the ring fingers stop at the distal palmar crease Likewise, the digital sheath of the thumb is continuous with the radial bursa The radial and the ulnar bursae communicate in certain cases, and such an arrangement is depicted here This arrangement determines the spread of infection in the synovial sheaths

The *fascial spaces* described by Kanavel are illustrated in C, and again in D The most important is the *midpalmar space,* which is bounded dorsally by the fascia over the interossei in the fourth and the fifth spaces, anteriorly by the fascia and the synovial sheaths of the flexor tendons, radially by a fascial membrane extending from the lateral border of the palmar fascia to the third metacarpal bone, and ulnarward by a similar membrane from the ulnar border of the palmar fascia to the fifth metacarpal

The *thenar space* is second in importance and lies between the midpalmar space and the thenar muscles Its dorsal boundary is the fascia overlying the adductor pollicis, while the lateral fascial membrane of the midpalmar space forms its anterior and medial wall

Both the midpalmar and the thenar spaces are shown in the cross section D The *hypothenar space* exists in the intermuscular planes of the hypothenar muscles and is of least importance

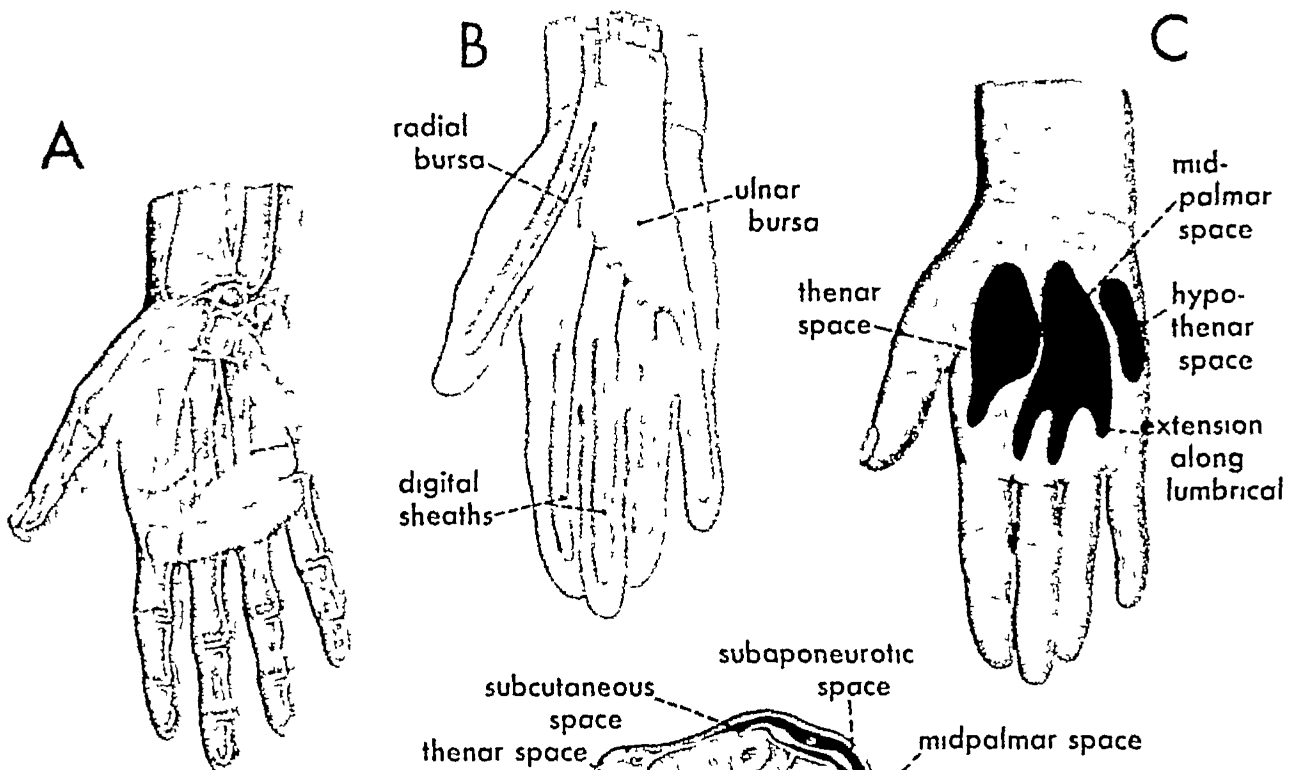
These spaces determine the planes of spread of pus in these situations As will be seen in C, there is a prolongation along the lumbrical canals, which anatomic path is utilized in surgical drainage Further, the midpalmar space is continuous through the carpal tunnel into *Parona's space,* deep to the flexor tendons in the forearm

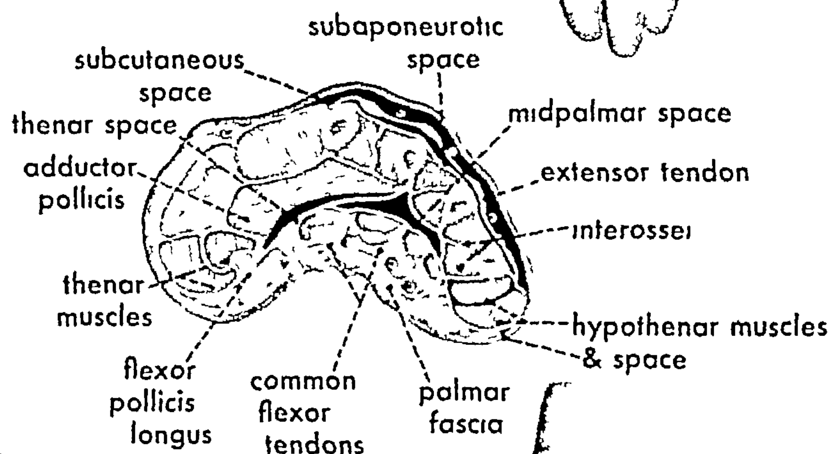
Figure D also shows the two *dorsal fascial spaces* superficial and deep to the extensor tendons and designated *subcutaneous* and *subaponeurotic* fascial spaces, respectively

Figure E illustrates the incision and the exposure for the cure of a *trigger finger* This interesting disorder can affect any digit, but here it is shown for the middle finger It is caused by a discrepancy in the size of the tendon mass entering the proximal portion of the thecal canal The basic lesion may be a thickening of the tendon mass or a narrowing of the thecal canal following trauma or low-grade inflammation

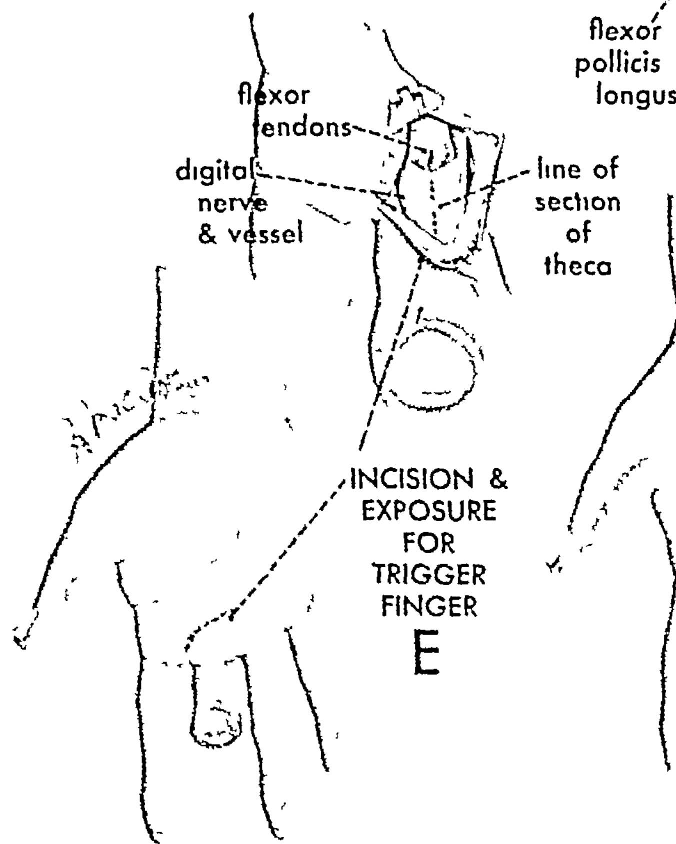
The area is exposed through a short incision in the distal palmar crease By movements of the digit, the exact mechanism can be visualized Cure is effected by a longitudinal incision in the proximal portion of the theca, as indicated

Figure F shows one of the type incisions and a step in the resection of the palmar fascia for Dupuytren's contracture In this advanced case extending into the ring finger, the digital thickening would require a separate exposure and subsequent resection through a second mid-lateral incision Care must be taken to remove the whole of the palmar fascia with its prolongations down to the metacarpal bones and the area of the thecal sheaths of the flexor tendons In this deeper dissection, injury to the digital nerves and vessels must be avoided



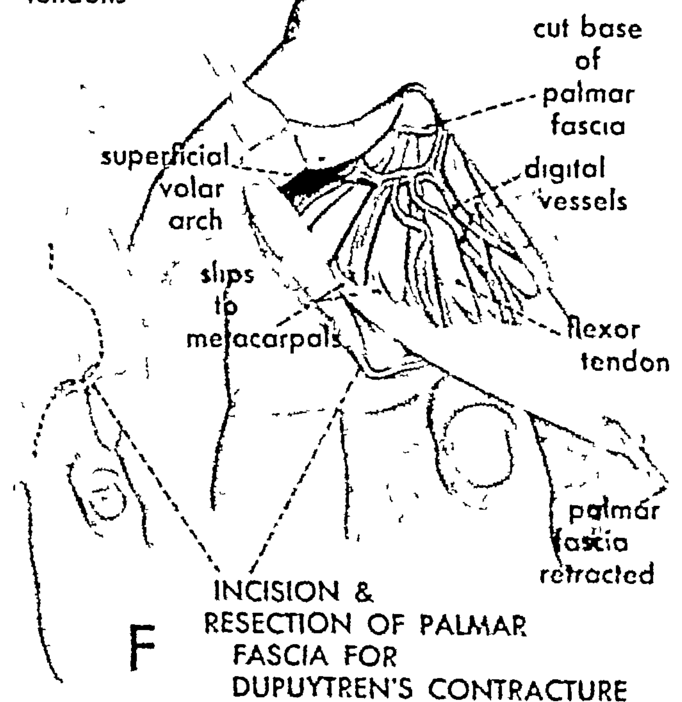


CROSS SECTION THROUGH BASES OF METACARPALS D



INCISION & EXPOSURE FOR TRIGGER FINGER

E



F

INCISION & RESECTION OF PALMAR FASCIA FOR DUPUYTREN'S CONTRACTURE

PLATE 36

Posterior Relations of the Wrist and the Hand

Plates 36 and 37 will detail the anatomic structures as studied from the posterior aspect and will illustrate some of the clinical applications of this knowledge

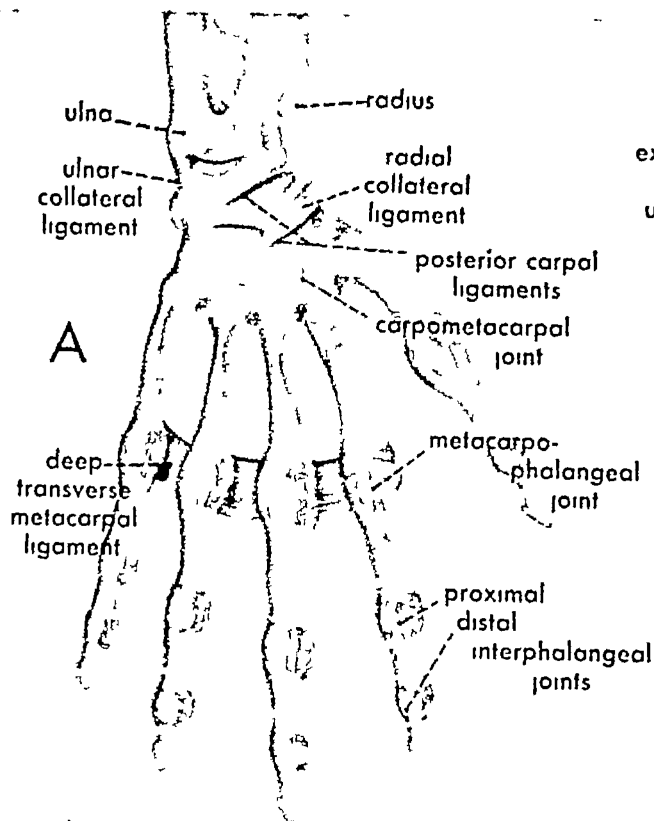
The first plate manifests the greater simplicity of the dorsal as compared with the volar aspect of the wrist and the hand

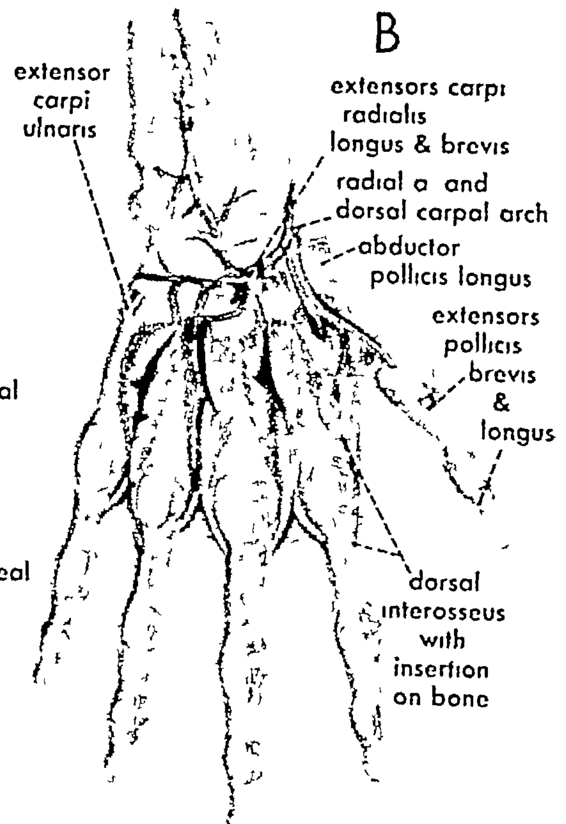
Figure A shows the skeletal framework and the ligamentous arrangements Attention should be directed to the transverse metacarpal ligaments which separate the palmar structures in the web spaces from those on the extensor aspect

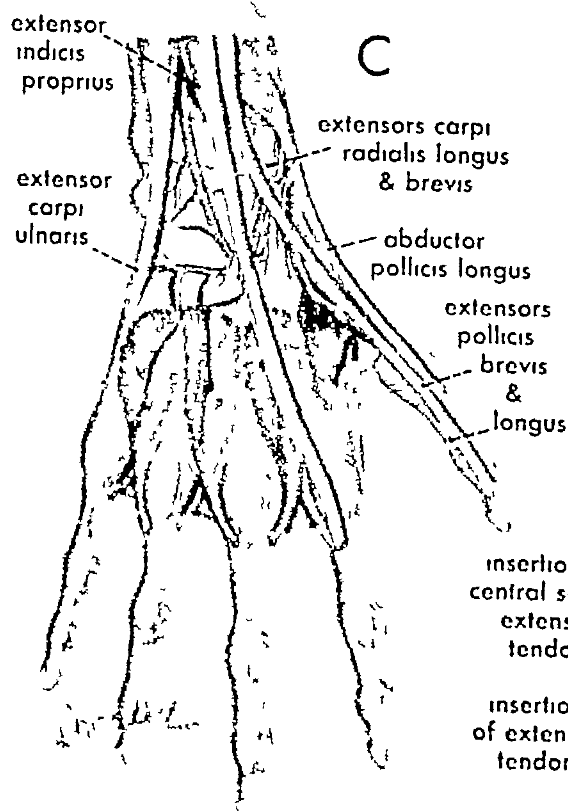
The interosseous muscles are added in B The insertions into the bases of the proximal phalanges can be seen, as also the sectioned slip which inserts into the dorsal extensor expansion The insertions of the tendons on the thumb, the abductor longus and the extensors brevis and longus are shown, as also those for the extensors carpi radialis longus and brevis and the extensor carpi ulnaris The dorsal carpal arch with its formation by the radial and the dorsal interosseous arteries is also indicated

Figure C completes the tendons whose insertions were shown in B and also adds the extensor indicis proprius

In Figure D, the extensors digitorum communis and digiti quinti have been added Special attention should be given to the extensor apparatus on each digit On the little finger, the insertions of the central slip and the fused lateral slips of the extensor expansion are shown On the *ring finger,* the tendons are seen completed, while on the *middle finger* the dorsal hood over the metacarpophalangeal joint and the dorsal expansion over the proximal phalanx, including the insertions of the interossei and the lumbricals, have been completed The *index finger* shows the addition of the arterial circulation and the nail The *thumb* is represented with its completed extensor apparatus


A
ulna
radius
ulnar collateral ligament
radial collateral ligament
posterior carpal ligaments
carpometacarpal joint
deep transverse metacarpal ligament
metacarpo-phalangeal joint
proximal
distal
interphalangeal joints


B
extensor carpi ulnaris
extensors carpi radialis longus & brevis
radial a and dorsal carpal arch
abductor pollicis longus
extensors pollicis brevis & longus
dorsal interosseus with insertion on bone


C
extensor indicis proprius
extensor carpi ulnaris
extensors carpi radialis longus & brevis
abductor pollicis longus
extensors pollicis brevis & longus

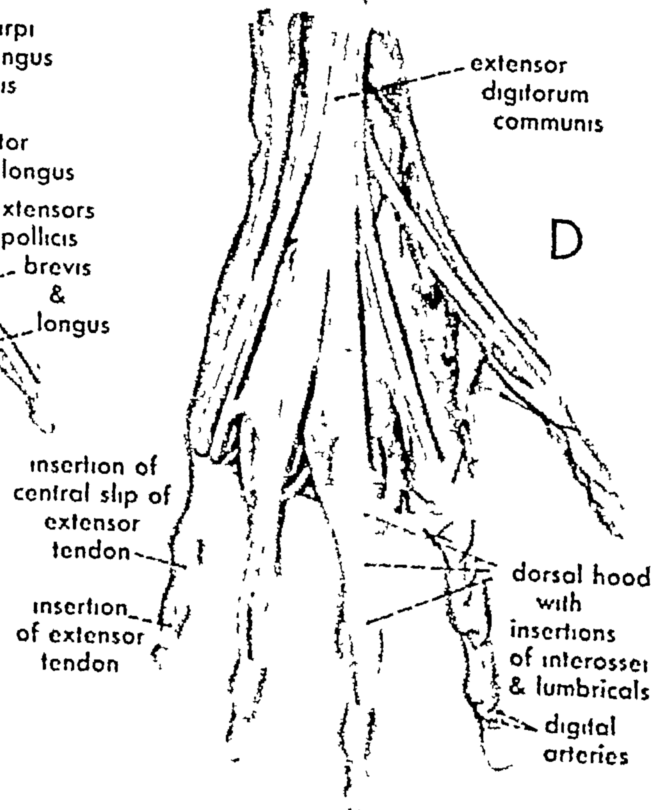

D
extensor digitorum communis
insertion of central slip of extensor tendon
insertion of extensor tendon
dorsal hood with insertions of interossei & lumbricals
digital arteries

PLATE 37

Clinical Applications of the Dorsal Anatomy

This plate illustrates the completion of the anatomic relations, together with certain standard surgical applications of this knowledge

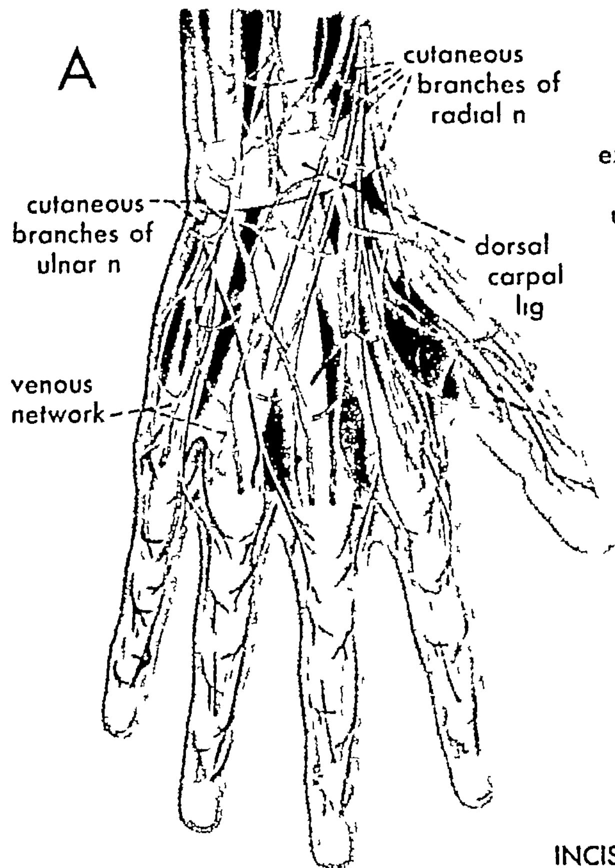
Figure A shows the final assembly of the structures on the dorsal aspect The dorsal carpal ligament, the cutaneous branches of the radial and the ulnar nerves, and the venous network have been added

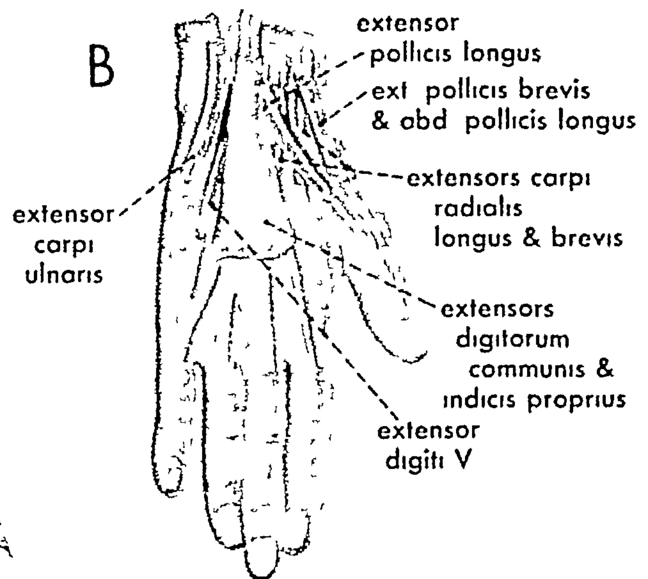
The synovial sheaths of the extensor tendons are not so extensive, nor do they suffer from infective and other disorders as frequently as the flexor sheaths Their extent is shown in Figure B

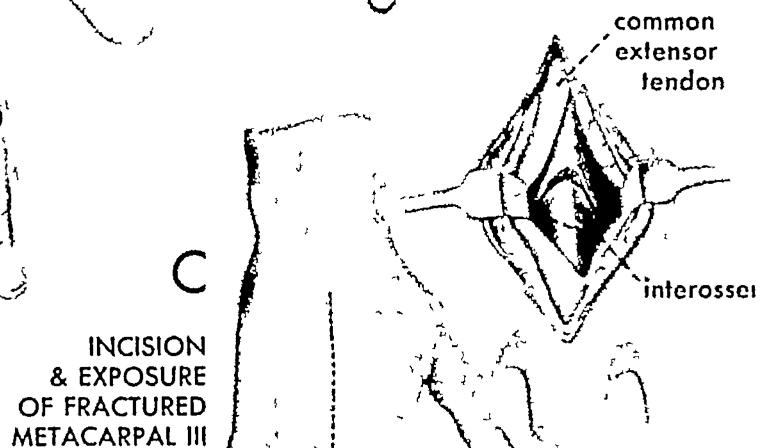
Figure C depicts the incision and the exposure of the third metacarpal shaft Exposure of the metacarpals may be required for the reduction of displaced fractures and sometimes for infective processes or neoplasms The bone is superficially placed, and the incision parallels its long axis The extensor tendon is located and retracted, exposing the shaft clothed on each side by the interossei

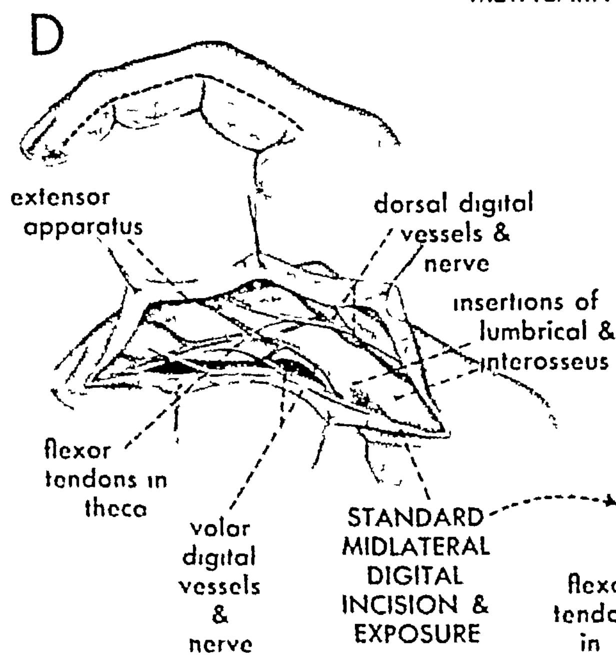
Figure D represents the standard mid-lateral incision on the digit which is employed for most procedures on the tendons, the nerves and the bones of the fingers The skin has been undercut much more widely than is done in practice to permit visualization of the relations of the digital vessels and nerves to the flexor and the extensor tendons The insertions into the dorsal hood of the lumbrical and the interosseous tendons are visible in the proximal part of the wound The cross section E indicates that the incision passes between the dorsal and the volar sets of the digital nerves and vessels

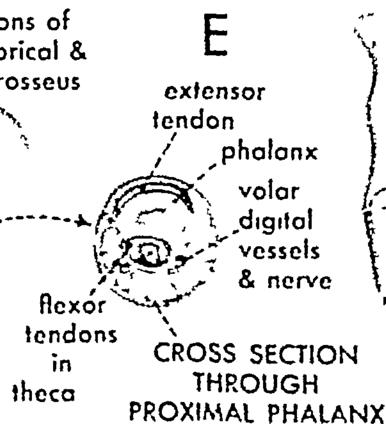
Avulsion of the extensor tendon is a common surgical problem Conservative treatment in a splint has not proven to be very satisfactory Figure F depicts the incision used for exposure of this area and the Bunnell method of repair by removable wire sutures The tendon is held under a raised flap of bone on the base of the distal phalanx by a suture passed through two drill holes to be tied over a button on the pulp surface The second suture is the one for removal of this retention suture 3 to 4 weeks later


A
cutaneous branches of radial n
cutaneous branches of ulnar n
dorsal carpal lig
venous network


B
extensor pollicis longus
ext pollicis brevis & abd pollicis longus
extensors carpi radialis longus & brevis
extensor carpi ulnaris
extensors digitorum communis & indicis proprius
extensor digiti V


C
common extensor tendon
interossei
INCISION & EXPOSURE OF FRACTURED METACARPAL III


D
extensor apparatus
dorsal digital vessels & nerve
insertions of lumbrical & interosseus
flexor tendons in theca
volar digital vessels & nerve
STANDARD MIDLATERAL DIGITAL INCISION & EXPOSURE


E
extensor tendon
phalanx
volar digital vessels & nerve
flexor tendons in theca
CROSS SECTION THROUGH PROXIMAL PHALANX

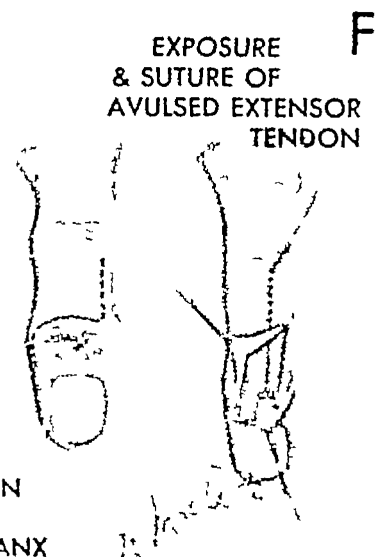

F
EXPOSURE & SUTURE OF AVULSED EXTENSOR TENDON

PLATE 38

Radial Relations and a Clinical Application

The radial side of the wrist and the hand is more highly specialized than the ulnar side The thumb and the index finger are of the greatest importance in all the functions of the hand, without them the patient is greatly handicapped For this reason they are sometimes referred to as the "eyes" of the hand Of these two digits, the thumb is of the greater value, as without it the remaining fingers have no surface for opposition, and the ability to pinch is lost The value of the fingers, therefore, decreases as one passes from the index to the little finger Loss of the index can be replaced by functional adaptation of the middle finger The anatomic relations of the thumb and the index finger, therefore, merit a separate series of illustrations

The structures in the first metacarpal space are shown in B The volar muscles are the adductor pollicis and the first lumbrical The tendon of the adductor inserts into the sesamoid and sends a slip to insert into the dorsal hood of the thumb, as shown in D The tendons of the first lumbrical and dorsal interosseus are shown sectioned in B and fusing with the dorsal extensor expansion in C The long tendons to the thumb, the abductor longus, the extensors brevis and longus, whose insertions are indicated in B, are completed in C Details of the arrangement of the flexor and the extensor apparatus for the index finger are represented The cut flexor sublimis tendon is drawn away from the bone to show the profundus tendon passing between its two slips This drawing C also depicts the contribution of the interosseous and the lumbrical muscles to the dorsal expansion

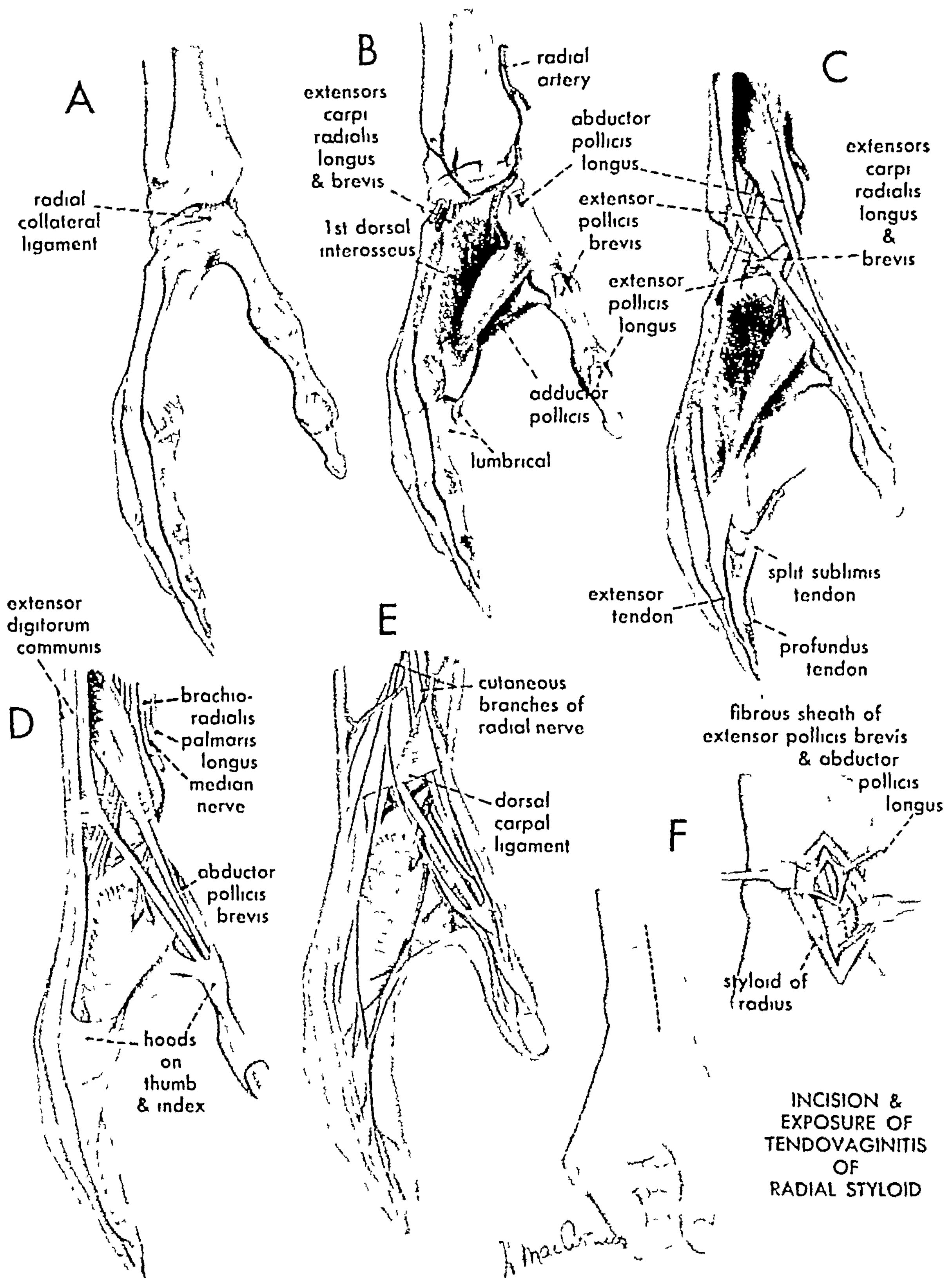
Figure D shows the important hoods in relation to the metacarpophalangeal joints of the thumb and the index finger The hood serves to fix the dorsal tendon and prevents the side-to-side slipping in the various positions of flexion occurring at this joint It is continuous with the dorsal extensor expansion On the thumb the contribution of the abductor pollicis brevis to its hood is added

The deep portion of the dorsal carpal ligament binding the tendons of the thumb to the radius should be noted

The radial artery passes through the anatomic snuff box and pierces the first dorsal interosseous muscle to complete the deep volar arch This vessel is seen in B, C, D and E Figure E also shows the radial nerve and its cutaneous branches to the thumb and the index finger

Tendovaginitis of the radial styloid is an interesting lesion first described by de Quervain The pathologic finding is a thickening of the fibrous sheath over the abductor pollicis longus and the extensor pollicis brevis tendons This is visible clinically as a diffuse swelling localized to this area, and the patient complains of an increasing and constant ache radiating along the extensor aspect of the thumb

A cure is readily secured by section of the constricting sheath A longitudinal or a transverse skin incision may be used The author prefers the longitudinal incision The radial nerve can be more easily avoided by this means The thickened fibrous sheath is exposed and sectioned longitudinally, as indicated in F



INCISION & EXPOSURE OF TENDOVAGINITIS OF RADIAL STYLOID

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1½ reels, 16 mm, silent color

Procurable from Lyon K Loomis, M D, 116 S Jefferson Davis Parkway, New Orleans, La

10

THE TRUNK

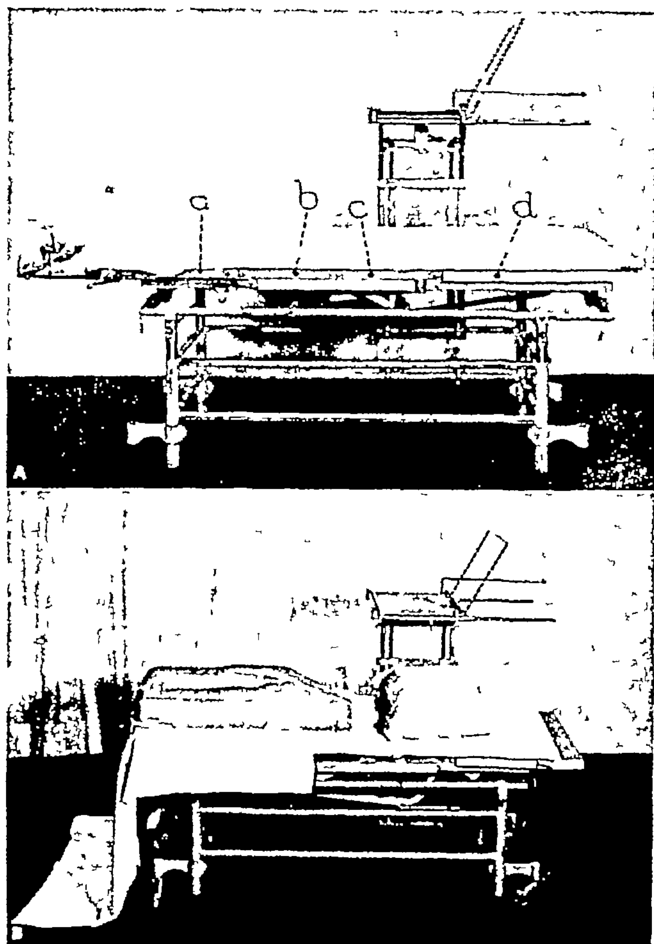


FIG 32 Operating table

(A) Straight position, covered with conductive rubber mattress (a) Top panel, (b) fixed panel, (c) middle panel, (d) bottom panel (a) and (c) are hinged to (b), while (d) is hinged to (c)

(B) Shoulder-hip pads in position, upon which the patient will lie prone

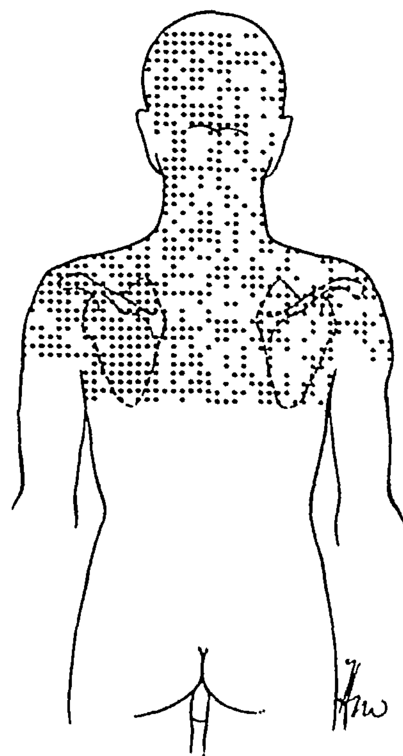


FIG 33 Area of skin preparation for operative procedures on the cervical spine

The area of skin preparation extends from the top of the head to the lower angles of the scapulae, including the posterior aspects of both shoulders and the lateral aspects of the neck Some centers prefer to shave the whole head, while others are content with shaving the area indicated

INDICATIONS FOR VARIOUS EXPOSURES

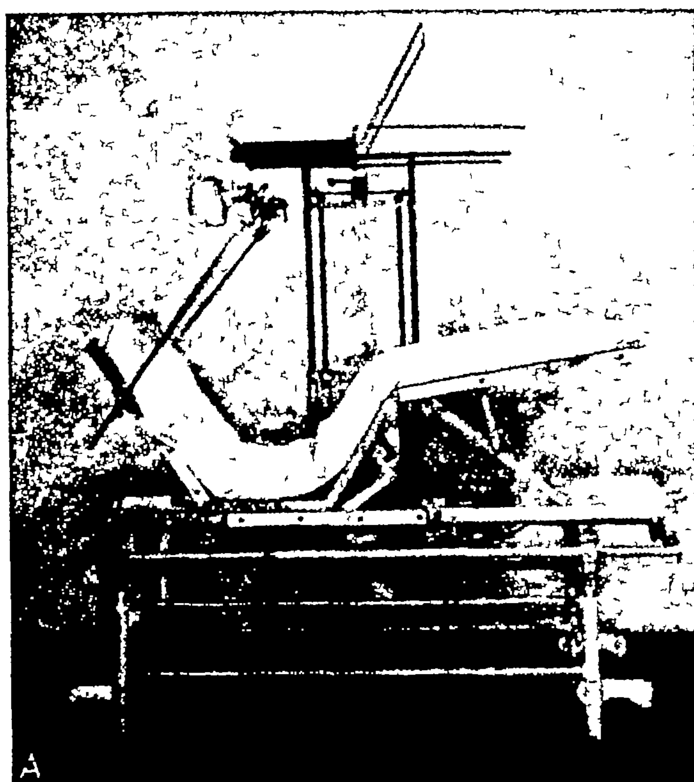
The early surgical procedures were chiefly laminectomies to relieve or remove pressure from the cord, whether traumatic or neoplastic in nature Instability of the spine resulting from trauma or paralysis was treated by arthrodesis, the technic of Albee and Hibbs being used Tuberculous abscesses in the dorsal region complicated by paraplegia were sometimes evacuated, or the cord was decompressed by laminectomy, but generally a conservative approach prevailed

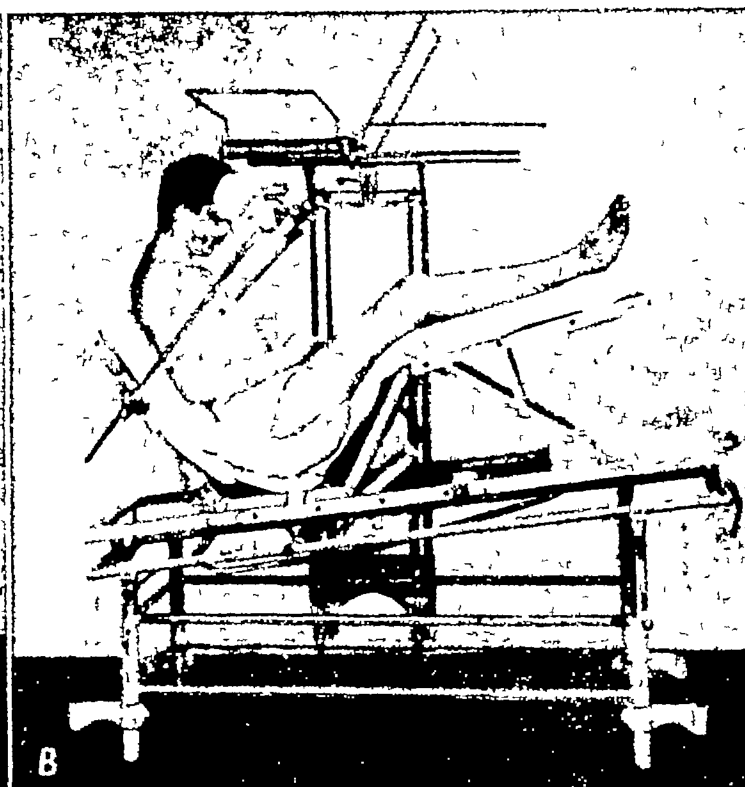
Increasing specialization and the antibiotic drugs have been responsible for a great extension

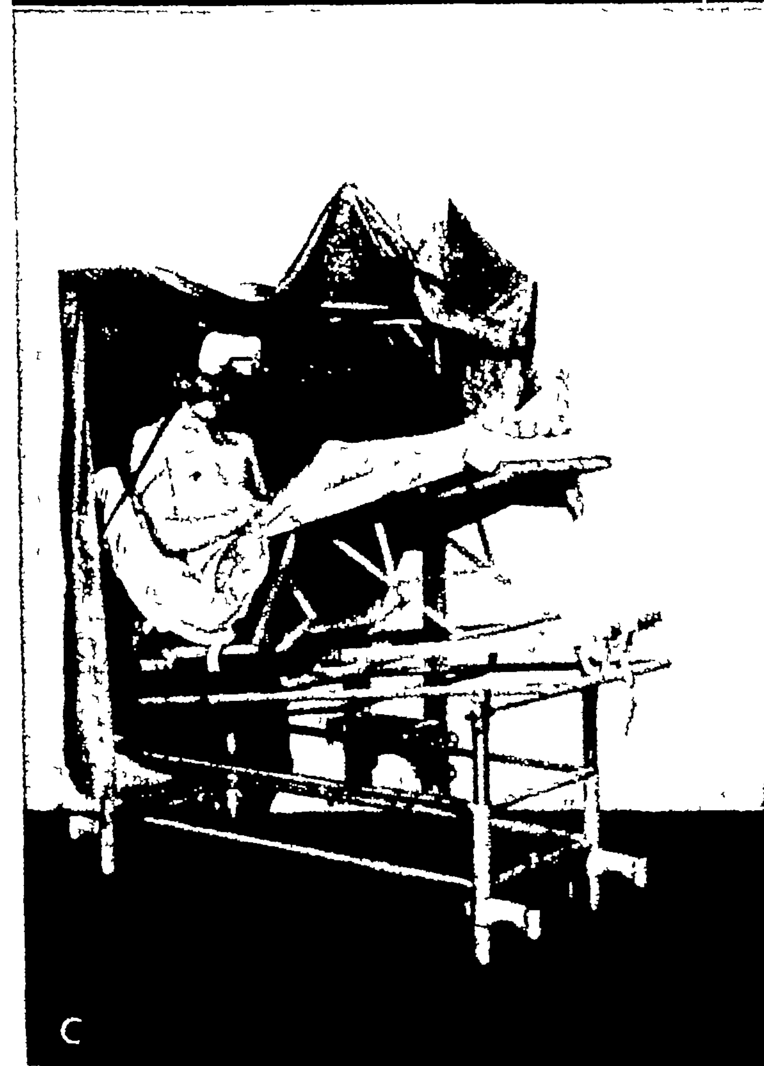
FIG 34 *(On facing page)* Cervical exposure Posturing and draping for sitting position

The patient is transported on to the table while flat, after which the posture is developed gradually, commencing by elevation of the legs

(A) Table in final sitting position (B) Patient in place (C) Anesthetist's aspect when patient is draped (D) Surgeon's view after draping


A


B


C


D



FIG 35 Cervical exposure Posturing and draping for prone position
(A) Patient arranged on table with shoulder-hip pads in place and forehead on rest Note flexion of cervical spine and counterelevation of legs
(B) Close-up of cervicodorsal view
(C) Arrangements for fracture-dislocation of cervical spine with tong traction *Note* (a) Weight attached to caliper, (b) well-secured endotracheal tube, (c) intravenous infusion running, (d) cautery attached, (e) electronic blanket
(D) Draping complete (a) Operative site, (b) instrument tray

of orthopedic and neurosurgical procedures Traumatic lesions, such as subluxations, dislocations and depressed or displaced fractures, causing pressure on the cord or the nerve roots, now receive emergency operative care The fundamental work of Schmorl, in the anatomic laboratory, detailing the life characteristics of the intervertebral disk was disseminated through the English-speaking world by the report of Beadle and applied clinically by Mixter and Barr The ecchondromata of the vertebral canal, long noted by neurosurgeons, assumed a new significance, and disk disease and prolapse have become household concepts The great rush to include this field of surgery in this or that specialty has now subsided The sobering end-result studies of insurance and compensation boards have brought about a more conservative approach to this problem There is a tendency for the "blind men and the elephant" attitude to give way to a broader concept, in which the disk lesion is interpreted in relation to the vertebral column and the patient as a whole With this has come the question of more localized fusion operations, such as the interbody arthrodesis of Cloward

Orthopedic surgeons have also become more conservative in their approach to lumbosacral fusion and recognize the difficulty of successful arthrodesis in this area

Corrective measures associated with extensive

arthrodeses are being performed for scoliosis and instability following paralysis Corrective osteotomy of the spine has been carried out for marked flexion deformity resulting from ankylosing spondylitis Bone-graft fixation is utilized for spondylolisthesis

Finally, attention should be given to the more radical approach to tuberculous disease of the vertebral column With the protection of antibiotics and chemotherapy, abscesses and areas of gross disease are cleared out, and direct local instillation by catheter of the antibiotics and enzymes is directed to the locus affected, with considerable improvement in results

The above remarks will suggest some of the indications for which the exposures which follow can be utilized

POSTURING AND DRAPING FOR SPINAL OPERATIONS

The conceptions here reproduced are the outcome of evolutionary changes in the methods practiced at the Montreal Neurological Institute

The technics described are due in great part to the ideas, the observations, the advice and the seemingly inexhaustible industry of Dr Wilder Penfield, Dr W V Cone and Dr Arthur Elvidge To these names should be added those of past operating-room supervisors and that of our present one, Miss Margaret Haggart

General Principles

The fundamental principles which guide procedures on the vertebral column may be divided into those considerations which are of importance (1) to the patient (2) to the surgeon, (3) to the anesthetist and (4) to the operating-room nurse

1 **The patient is postured either sitting or prone** The adoption of either position in the case of the anesthetized patient, especially over prolonged periods may interfere with the normal physiologic equilibrium Either position may affect adversely the cardiovascular or the respiratory system The sitting posture therefore is selected only for those patients in essentially good health When the prone position is used, shoulder-hip pads of sponge rubber are so arranged there is a minimum of interference with th spiratory system

In either position, if general anesthesia is such is maintained at a plane as light as pos to depress to a minimum the circulation an respiration

The particular position adopted is checke fore the operation in order to avoid such plications as postural palsies, pressure sores cautery burns

An intravenous infusion utilizing an 18- 16-gauge needle, is started prior to the mencement of the operation in order that necessary intravenous therapy may be given out delay In some instances it is necessary to form a cut-down

When the position of the patient is finall spected, it is ascertained that there is no u pressure on the jugular veins, while that ex on the inferior vena cava is minimal

2 **From the surgeon's point of view** must be free access to the operative field wit possibility of contamination Allowance mu made for the surgeon to take as long as is essary, and means should be provided for hi be in as comfortable and as untiring a pos as possible Draping and lighting should b ranged to minimize eyestrain There mus facility to use the diathermy cautery while ticulous hemostasis should ensure a bloo field.

3 **From the anesthetist's point of view** medication should be controlled to avoid un essary respiratory depression or delayed reco

There must be free access at all times to patient's airway The airway must be perfect fixed in such a way that it cannot become ranged unintentionally. Apparatus should b hand so that endotracheal aspiration can be ried out if and when necessary Means mus available to assist or control respiration Res tory obstruction, hypoxia and hypercarbia be avoided There must be perfect and acces control over intravenous therapy.

4 **The Position of the Nurse** The n must have an unimpeded position adjacen

PLATE 39

Posterior Relations of the Cervical Vertebrae

The neck supports the head on the trunk Its skeletal framework is formed by seven cervical vertebrae containing the cervical enlargement of the spinal cord This isthmus of the human frame, through which course the vascular channels to the brain, has always been a vulnerable area of the body The sharp edge of the executioner's medium, the hangman's noose and the sleeper hold of the professional wrestler have each used these anatomic factors to their own particular end

The first cervical vertebra, or atlas, supports the cranium and articulates with the occipital bone This articulation permits the nodding movements

The second cervical vertebra, or axis, articulates through the odontoid process with the atlas and affords the motion of rotation These two bones are deeply placed and their exposure is difficult, as shown in Plate 40

The third to the seventh cervical vertebrae are placed more superficially They permit the movement of lateral deviation from the midline The facet articulations are arranged obliquely and are subject to subluxation and dislocation Degenerative changes are especially prone to occur in the disk spaces of C 4-5 and C 5-6

The cervical enlargement of the spinal cord practically fills the vertebral canal in this region For this reason, injuries causing encroachment on the vertebral canal are prone to produce pressure on the cord The phrenic nerve arises from C 3, 4 and 5, and the respiratory center is in the medulla Acute pressure on the cord can, therefore, cause death by respiratory failure

These preliminary remarks serve to introduce the descriptions of the six drawings depicting the anatomic relations of the cervical vertebrae, as seen from the posterior aspect

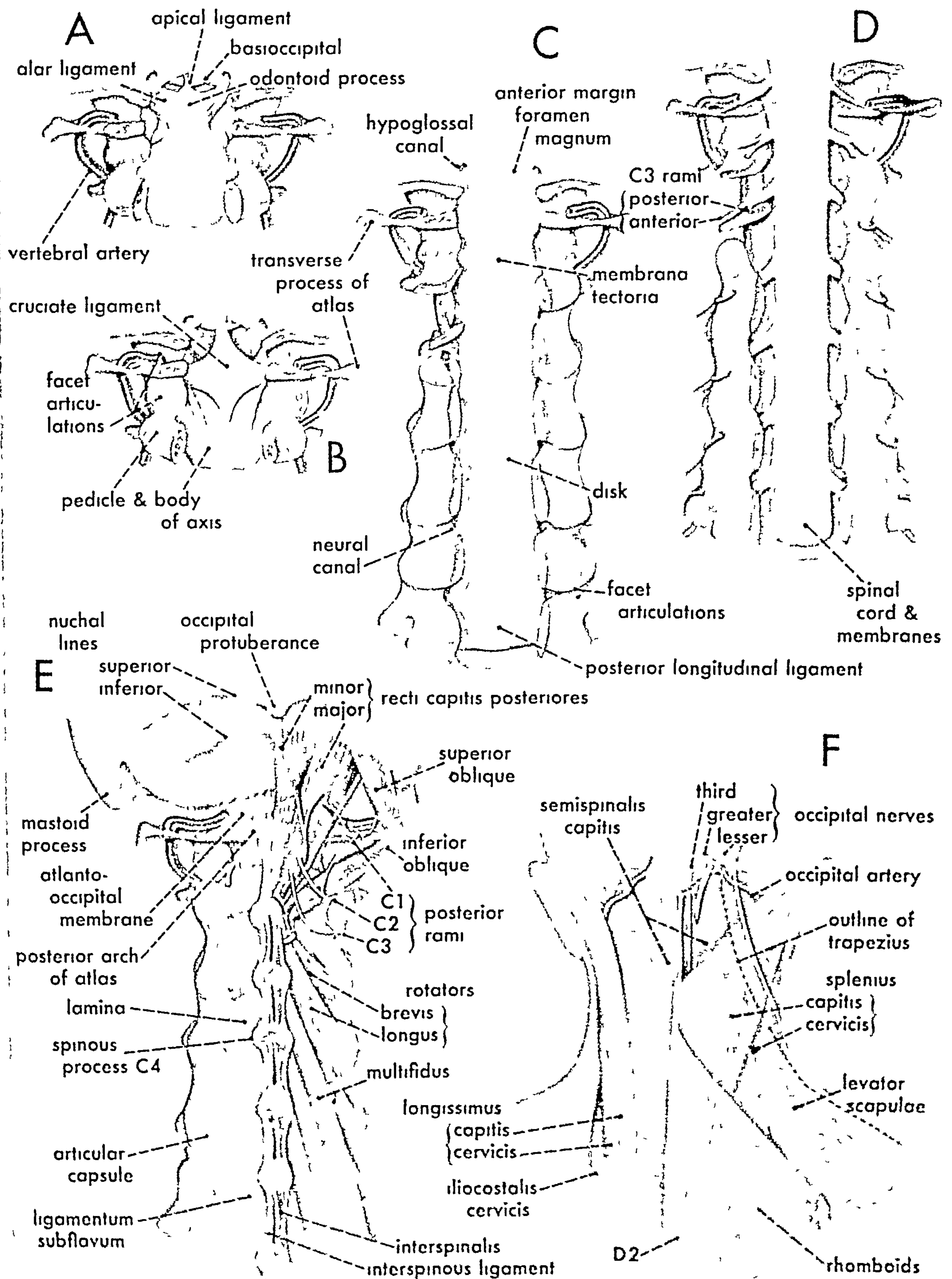
Figures A and B detail the arrangement of the atlas and the axis to each other and to the basioccipital and the foramen magnum It will be helpful to remember that the odontoid process corresponds to the body of the atlas and articulates with its anterior arch It can be seen how easily fracture of the odontoid process with displacement could cause cord damage This bony projection of the axis is, however, well anchored by the apical, the alar and the cruciate ligaments

Figure C shows the anterior wall of the vertebral canal The membrana tectoria and the posterior longitudinal ligament cover the bodies of the vertebrae and their intervertebral disks, giving a strong but smooth lining on which the spinal cord rests, protected by the membranes On the left side, the bone has been removed from C 3 to show the articular facet of C 4, the whole extent of the neural canal and the close relationship of the vertebral artery to the intervertebral disks and the nerve roots Injury to this large artery can occur in operative removal of the disks

In Figure D, the spinal cord and the nerve roots covered by the dura mater have been added The full course of C 3 can be seen on the left, where the bone has been removed Note the division into the anterior and the posterior rami It will be observed that the roots of C 1 and C 2 only pass out posterior to the more anteriorly placed facets of the atlas and the axis Note also that the nerve roots lie at the level of the disks and the facet articulations

The musculature is added in Figures E and F In Figure E, the important small muscles of the suboccipital triangle are shown, namely, the superior and the inferior obliques and the recti capitis posteriores major and minor From a surgical point of view, the muscles covering the laminae and the transverse processes need not be detailed separately, as they are reflected subperiosteally en masse

On the left side in Figure F, the deeper layer of muscles formed by the semispinales capitis and cervicis, the longissimi capitis and cervicis and the iliocostalis cervicis are illustrated, while on the right side these are covered by the splenii capitis and cervicis, and below this by the serratus posterior superior covered in this drawing by the rhomboids Laterally, the levator anguli scapulae can be seen passing down to the superior angle of the scapula The outline of the trapezius muscle is indicated to complete the muscular components of this region The main branches of the posterior rami of C 2 (greater occipital) and of C 3 (third occipital) and branches of the anterior rami of C 2 and 3 (lesser occipital) with the occipital artery, all ascending over the superior nuchal line to supply the scalp, are added for completion of the anatomic structures of significance to the surgeon



A
apical ligament
basioccipital
alar ligament
odontoid process
vertebral artery
cruciate ligament
facet articulations
pedicle & body of axis
B
C
hypoglossal canal
anterior margin foramen magnum
transverse process of atlas
membrana tectoria
disk
neural canal
facet articulations
posterior longitudinal ligament
D
C3 rami
posterior
anterior
spinal cord & membranes
E
nuchal lines
superior
inferior
occipital protuberance
minor
major
recti capitis posteriores
superior oblique
inferior oblique
mastoid process
atlanto-occipital membrane
posterior arch of atlas
C1
C2
C3
posterior rami
rotators
brevis
longus
lamina
spinous process C4
multifidus
articular capsule
ligamentum subflavum
interspinalis
interspinous ligament
F
semispinalis capitis
third
greater
lesser
occipital nerves
occipital artery
outline of trapezius
splenius
capitis
cervicis
levator scapulae
longissimus
capitis
cervicis
iliocostalis cervicis
D2
rhomboids

PLATE 40

Relations and Posterior Exposures of the Cervical Vertebrae

This plate continues the visualization of the relations of the cervical vertebrae begun on Plate 39, and, in addition, depicts the application of this anatomic knowledge to the posterior exposures of the cervical vertebrae

Figure A presents the cervical vertebrae and the occipital bone with related ligaments, as seen in lateral view Note especially the ligamentum nuchae and the anterior longitudinal ligament The close relations of the cervical nerves, the vertebral artery, the facet articulations and the intervertebral disks are readily understood from this drawing

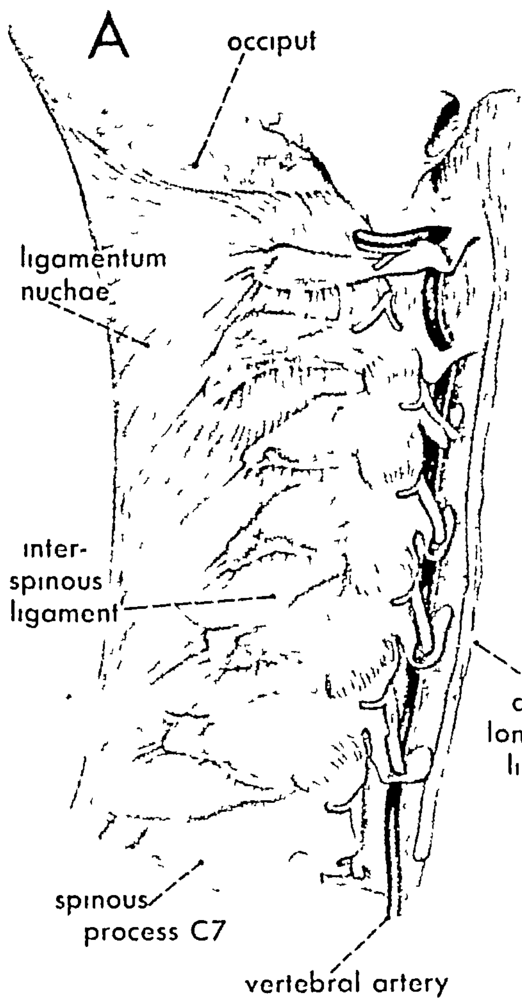
A cross section of the neck through the disk between C 4 and 5 is shown in Figure B This illustration serves as a reference for the various muscles and fascial planes in the other illustrations covering the cervical spine (1) Trapezius, (2) splenius capitis, (3) semispinalis capitis, (4) semispinalis cervicis, (5) spinalis cervicis and multifidus, (6) levator scapuli, (7) longissimus cervicis, (8) longissimus capitis, (9) scalenes, (10) sternocleidomastoid

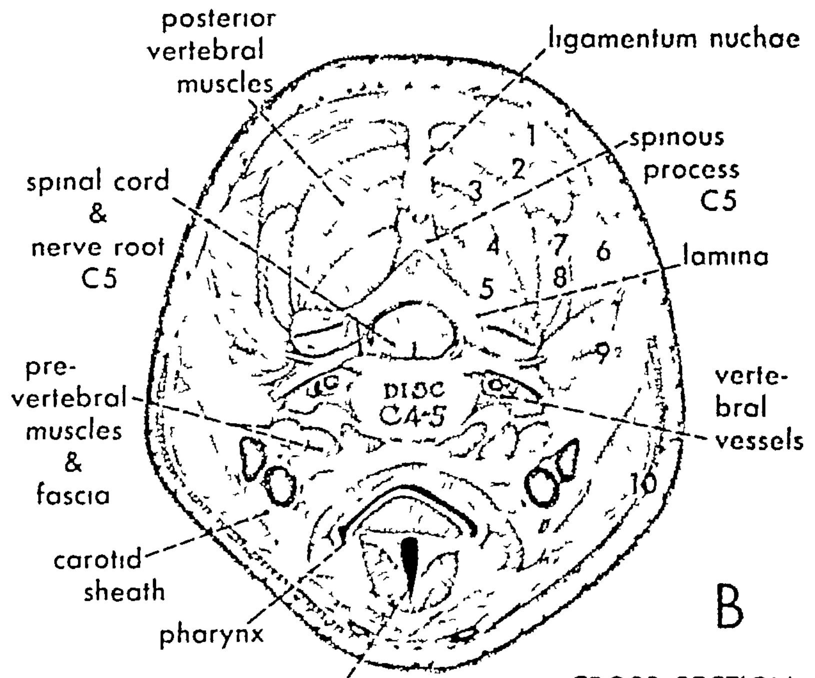
Figures C, D, E and F form a group of drawings to illustrate the exposure of a prolapsed disk at the level of C 6 and the exposure of the occipital bone and the upper three cervical vertebrae Utilizing either exposure, most of the necessary operative procedures on the cervical vertebrae and the cord can be performed Most commonly the indications are for fractures or fracture-dislocations, which require operative reduction and sometimes postreduction stabilization Fracture of the odontoid process should be mentioned in this respect, also congenital posterior displacment of this bony process Exposure may also be necessitated for root pressure from disk prolapse, most commonly in the lower spaces The exposures may be employed for laminectomy required for operative procedures on the cervical cc membranes, or to decompress the cord in ca pressure from fractures, fracture-dislocation: neoplastic lesions

Figure C shows the midline incision emp routinely The solid line is that for the exposı the laminae of C 5, 6 and 7, as further illustra D and E, and the broken line for the approach occipital bone and the atlas and the axis, as s in F

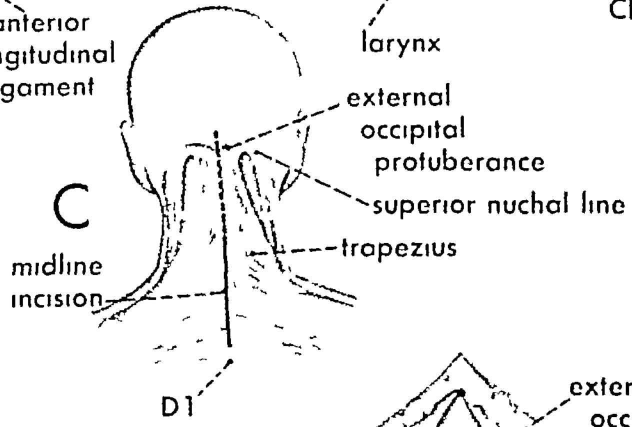
The golden rule—Get down to bone and stay —applies to the clean subperiosteal reflection (soft tissues from the spinous processes and the nae as far laterally as the facet articulations is performed unilaterally on the right side in F D The circular dotted line indicates the amou the laminae *and the ligamentum subflavum fo* tial removal This should extend laterally int facet articulation A prolapsed disk at the le C 6 is depicted in E to demonstrate the intima lations of the important structures found at su operation

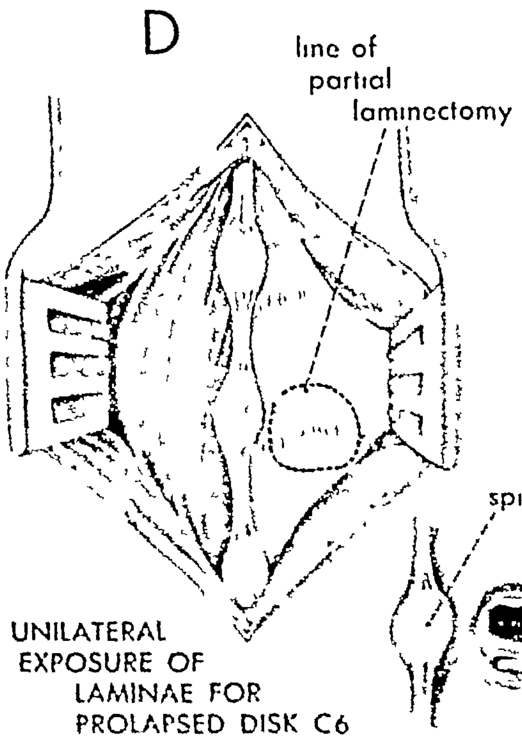
Figure F shows *the completed exposure of th* cipital bone and the posterior surfaces of the ı four cervical vertebrae The absence of a sp process on the atlas should be noted, as also the depth of these bones when exposed from the p rior aspect Here, too, the approach has been a line incision with subperiosteal reflection of al sues from the spinous processes and the midli the occipital bone, which reflection was conti more deeply and laterally until a wide area o occipital bone and the laminae and the interve ligaments were cleared as far as required for the cedure in hand Thus upper cervical fusion coul achieved by dual bone grafts



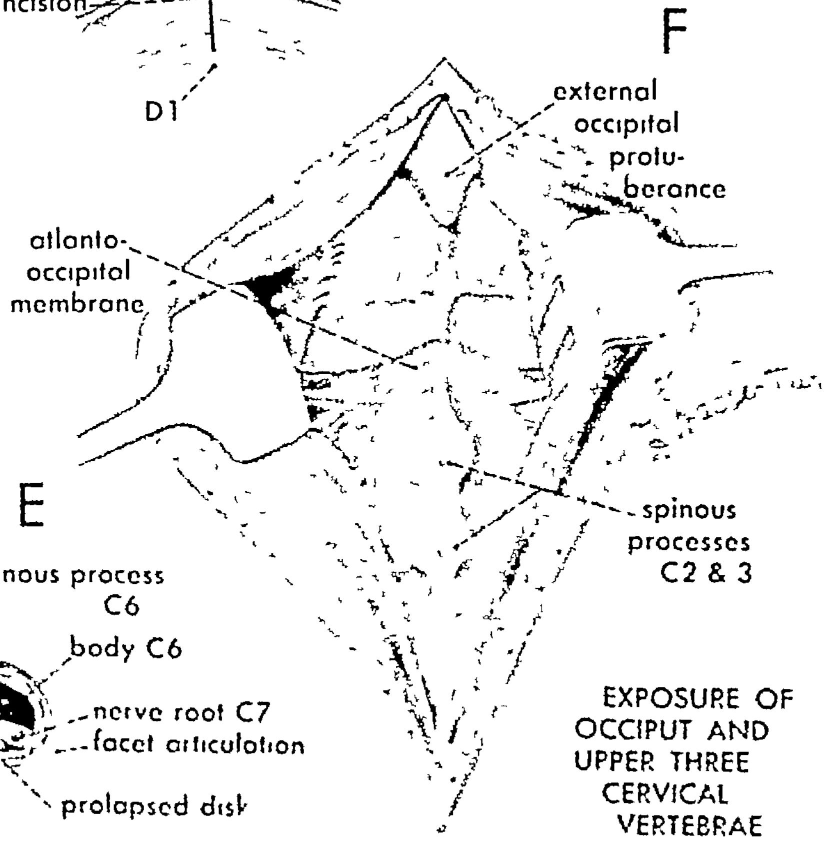


CROSS SECTION LEVEL C4 5





UNILATERAL EXPOSURE OF LAMINAE FOR PROLAPSED DISK C6



EXPOSURE OF OCCIPUT AND UPPER THREE CERVICAL VERTEBRAE

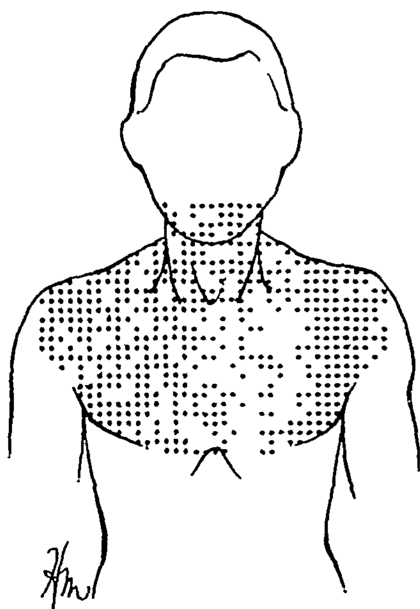


FIG 36 Area of skin preparation for scalenotomy and resection of cervical rib

The area of skin preparation includes the lower part of the face, the anterior and the lateral aspects of the neck, and the pectoral regions to just below the nipple line (For posturing and draping for these procedures, the reader is referred to Fig 7)

patient, surgeon and instruments She must be so stationed that the surgeon can receive every attention without taking his eyes from the operative field

PREPARATION

Operative Site Just prior to surgery the operative area is shaved and washed with pHisoHex After the correct posture has been arranged, a further pHisoHex preparation is carried out The area is finally prepared with 2½ per cent iodine tincture

Posturing General anesthesia is induced with the patient in his own bed Subsequently, the patient is transferred to the operating table and postured correctly Following preparation of the operative field, an electronic blanket is placed over the lower part of the body

Draping 1 After the skin preparation, Pliofilm in 22-in squares, previously autoclaved for 3 hours, is placed either over the site or round it If over it, an area of Pliofilm similar to that le exposed by the drapes which follow is cut fror the center

2 Double towels, usually four in numbe each 25 in square when doubled, are clipped o stitched round the site of operation

3 Large lower and upper double white shee drapes are next placed to cover the rest of th body

4 There follows a single-thickness green spl sheet, the split being placed cephalad

5 Finally, double green towels are placed tc cover any of the split which is exposed

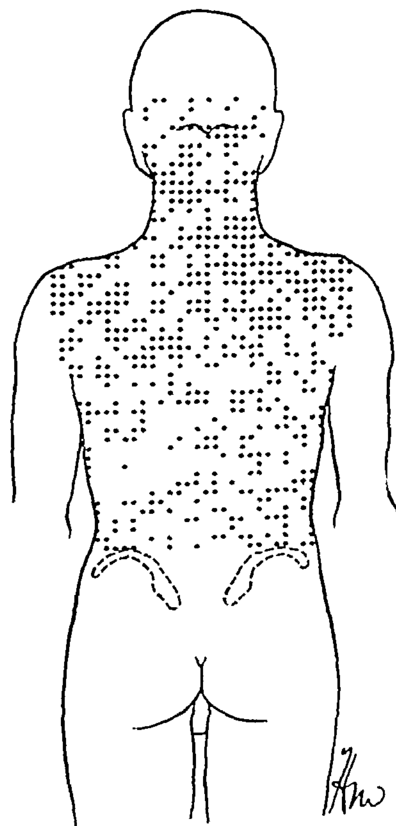


FIG 37 Area of skin preparation for operative procedures on the dorsal spine

The area of skin preparation extends from just above the external occipital protuberance to the iliac crest, although for the lower half of the spine it need not extend above the middle of the neck

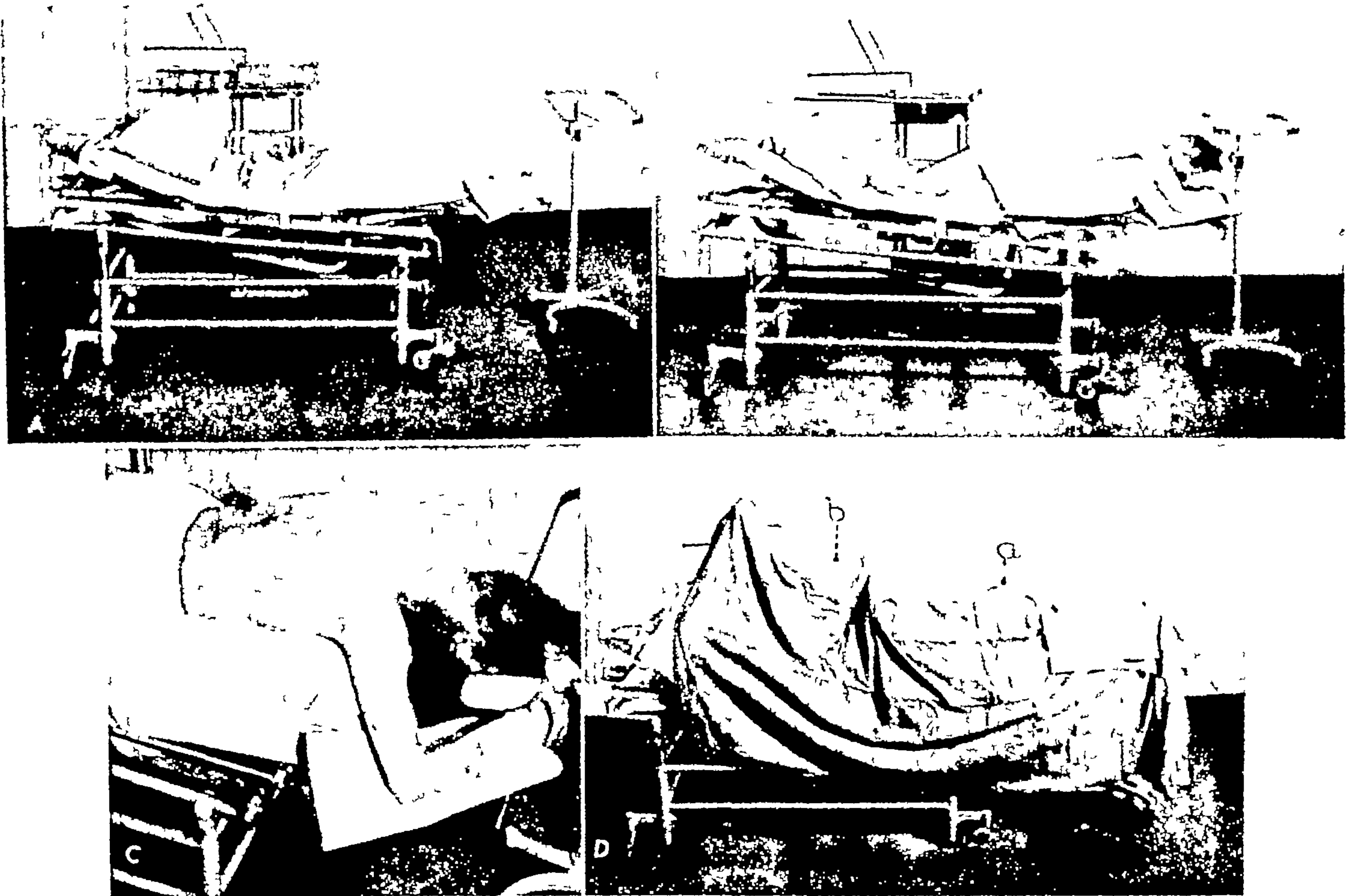


FIG 38 Thoracic exposure Posturing and draping
(A) Table arranged with head rest, shoulder-hip pads and pillow in position
(B) Patient in place with arms arranged to cause the scapulae to fall laterally and forward
(C) Close-up of area
(D) Draping completed (a) Operative area, (b) instrument tray

SURGEON'S PREPARATION

1 Overhead masks with Jel filters are worn

2 A pHisoHex scrub is carried out

3 The first pair of gloves, dusted with sulfathiazole powder, is put on to perform the final skin preparation.

4 The gloves are changed in order to supervise the draping after which they are discarded

5 Routine gowning then takes place, and a third pair of gloves is put on to commence surgery All assistants wear back vests

PLATE 41

Exposure for Scalenotomy and Resection of a Cervical Rib

The region deep to the clavicle, in the environs of the first rib, has a great fascination for those of an investigative type of mind Clinical syndromes originating at the junctions of the trunk with other parts of the body have always been the most difficult to understand This area is the most complicated, providing as it does the cervicobrachial and the thoracobrachial outlets which transmit the nervous and the vascular channels connecting the cervicodorsal spine and the heart with the upper extremity The clavicle, articulated with the trunk at the sternoclavicular joint, maintains through the tonic balance of the related muscles the level of the shoulder girdle and, through this co-ordinated activity, the tension on the vascular and the nervous channels, as well as the spatial relationships in the costoclavicular space The posture of the patient, reflected not only in the level of the shoulder girdle but also in the position of the head and the cervical spine as a second unit and the slope of the ribs of the thoracic cage as a third unit, affords further variables in the complex mechanics of this region Variations in the brachial plexus, whether prefixed or postfixed, and in the presence of the many types of cervical rib arrangements provide demonstrable bases for some of the pain syndromes arising in this area

This plate serves to illustrate the anatomic relations of this region as applied to the exposure of the scalenus anterior insertion and the cervical rib location, and also depicts how the subclavian artery and the first dorsal nerve may be compressed by mechanical factors

Figure A presents the scalene group of muscles inserted into the first and the second ribs Attention should be paid to the space between the anterior and the middle scalenes which permits the passage of the brachial plexus and the subclavian artery Note also the dome of the pleura covered by Sibson's fascia On the right side, the roots of the nerves C 5-8 and D 1 are shown, together with the adjacent sympathetic chain

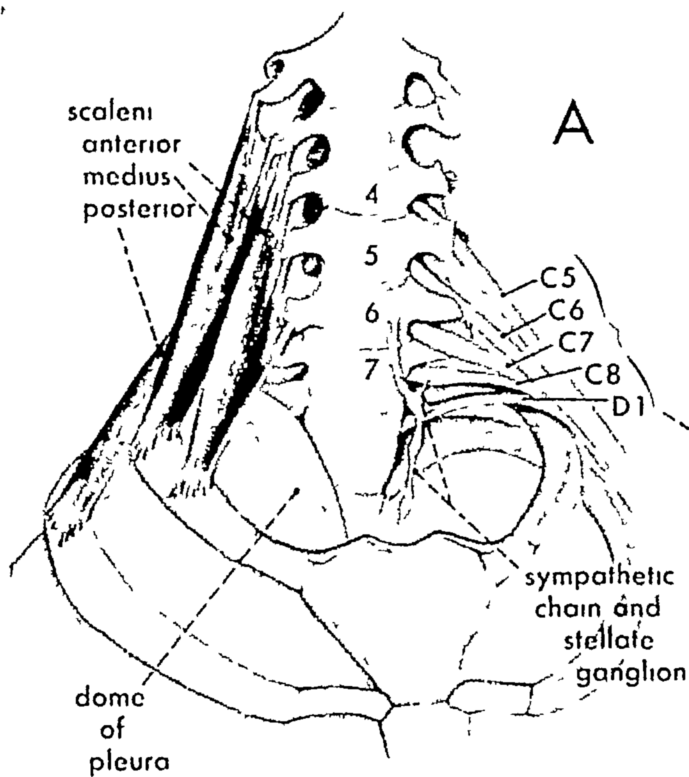
In Figure B, the vascular and the nervous channels are placed in their relationship to the muscular and the skeletal structures The clavicle is indicated by the dotted line, and it is readily seen how its position, whether elevated or depressed, retracted or projected forward, will alter the mechanical arrangements in the environs of the first rib

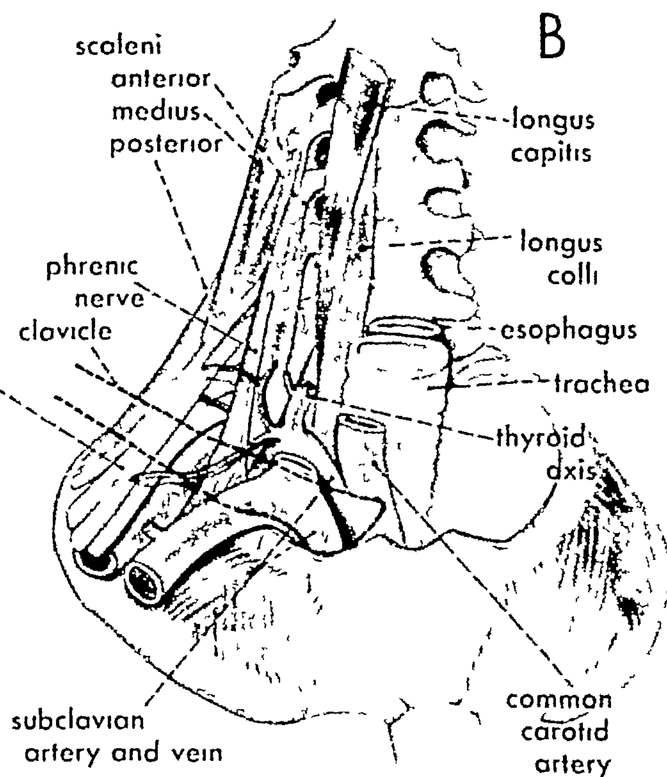
Figure C shows the completion of the soft-tissue build-up The clavicular and the sternal attachments of the sternocleidomastoid muscle should be studied with regard to their relation to the underlying structures

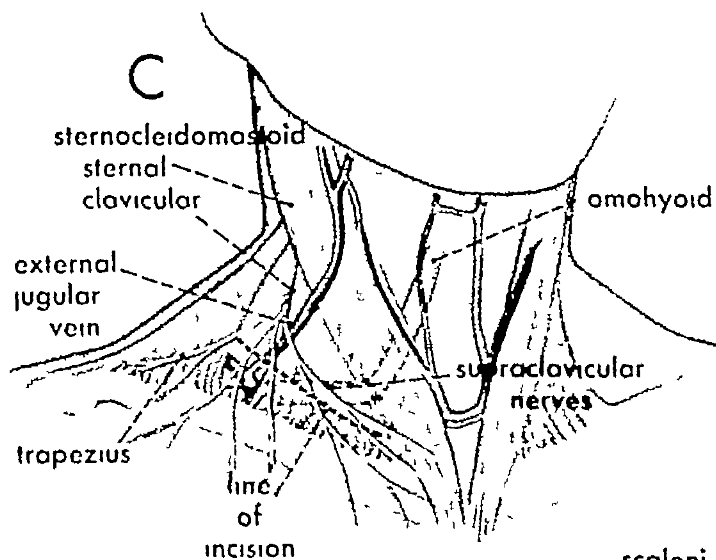
The exposure of the insertion of the scalenus anterior on the first rib is achieved through a transverse incision just above the clavicle (Fig C) The external jugular vein requires section or retraction backward Branches of the supraclavicular nerves are encountered as the platysma muscle is incised The clavicular portion of the sternocleidomastoid is divided and retracted forward By digital examination, the firm round tendon of the scalenus anterior can be palpated, and frequently also the phrenic nerve can be rolled on its surface These structures serve to guide the surgeon in his deeper dissection At this point a pad of fatty tissue is encountered over the scalene area and is separated carefully by blunt dissection The scalenus anterior, with the phrenic nerve on its surface, is now cleared down to its attachment on the first rib Palpation will localize the pulsation of the subclavian artery, and the subclavian vein will be found anterior, medial and inferior to the insertion of the scalenus anterior The exposure obtained is illustrated in Figure D Surgical procedures can now be executed as required If section of the scalenus anterior is desired, this should be performed through the relatively avascular tendinous portion This will enable the mobilization of the subclavian artery and the brachial plexus if a cervical rib merits resection

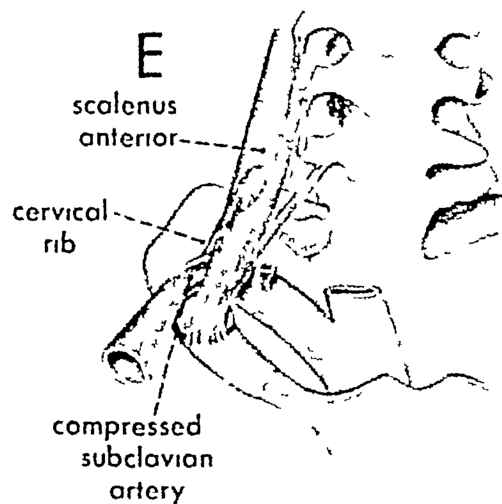
Figures E, F and G show the manner in which the subclavian artery and the lowest cord (C 8-D 1) of the brachial plexus are compressed when a cervical rib is attached to the first rib behind these channels Correlation with Figure A will indicate how the cord of D 1 is stretched up over the first rib and any abnormal bone or fibrous band related to the cervical rib

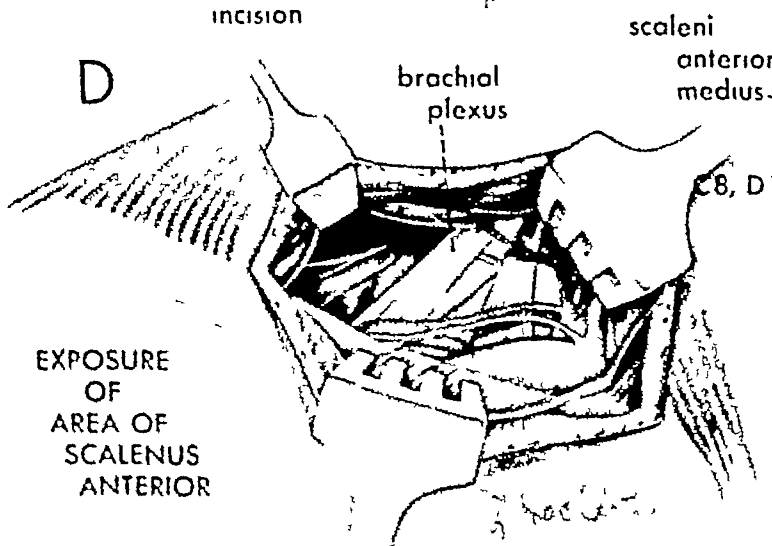
This exposure can thus be used for scalenotomy or resection of cervical rib or associated cartilaginous or fibrous structure, or for procedures on the phrenic nerve On the left side the approach has been employed for exploration of the termination of the thoracic duct, and on either side it can be utilized for operations on the subclavian vessels or cords of the brachial plexus


A
scaleni
anterior
medius
posterior
4
5
6
7
C5
C6
C7
C8
D1
sympathetic
chain and
stellate
ganglion
dome
of
pleura


B
scaleni
anterior
medius
posterior
longus
capitis
longus
colli
phrenic
nerve
clavicle
esophagus
trachea
thyroid
axis
subclavian
artery and vein
common
carotid
artery


C
sternocleidomastoid
sternal
clavicular
omohyoid
external
jugular
vein
supraclavicular
nerves
trapezius
line
of
incision


E
scalenus
anterior
cervical
rib
compressed
subclavian
artery


D
brachial
plexus
EXPOSURE
OF
AREA OF
SCALENUS
ANTERIOR

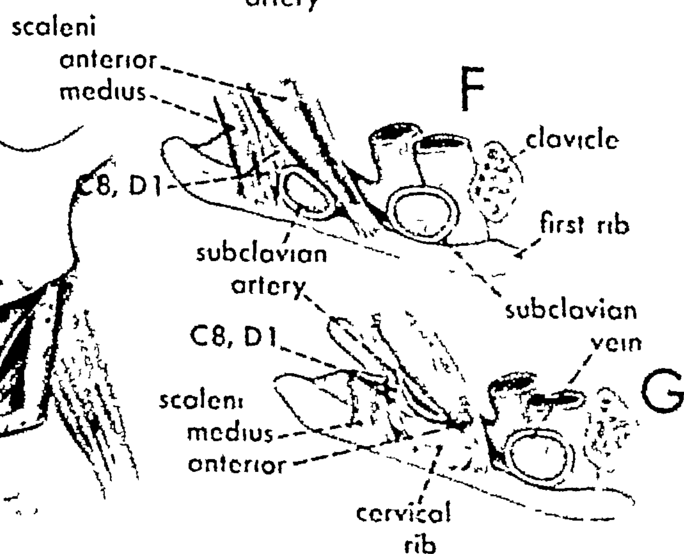

scaleni
anterior
medius
F
clavicle
C8, D1
first rib
subclavian
artery
subclavian
vein
C8, D1
G
scaleni
medius
anterior
cervical
rib

PLATE 42

Posterior Relations of the Dorsal Vertebrae

The twelve dorsal vertebrae form the posterior axis of the thoracic cage The twelve ribs on each side articulate with the bodies of these vertebrae, the upper ten ribs with the transverse processes as well The dorsal spine presents a primary curvature with its convexity directed posteriorly This plate illustrates the posterior relations of the vertebral column in this region and should be correlated with Plate 43, in which this knowledge is applied for the surgical exposures

Figure A shows the posterior aspect of the vertebral bodies with the pedicles sectioned and the arches removed The posterior longitudinal ligament is seen with its thicker central portion, which widens over the disks Note the intervertebral disks and the facets adjacent to their lateral surfaces for the costal articulations The basivertebral veins are prominent

In Figure B, the cord and the membranes have been added The dura mater has been windowed to show the formation of the nerve roots

Figure C represents a sagittal section of the dorsal vertebral column with the dura mater left *in situ* The anterior and the posterior nerve roots leave by separate apertures Note the curvature of the spine with posterior convexity Also note the increasing slope of the spines until the tenth is reached, where the transition to the lumbar type is visible The disks in the dorsal area are thinner than those in the cervical or the lumbar area Another point is that the cord practically fills the vertebral canal in this region, and pressure on the cord can readily occur from vertebral displacement or from expanding lesions within the vertebral canal

In Figures D and E, the posterior arches are replaced, and the soft tissues are built up on the skeletal framework In D, the left side shows the costotransverse articulation with the ligaments, the posterior rami of the dorsal nerves and the short muscles, the rotatores and the levatores costae On the right side of this drawing, the long muscles, namely, the longissimus, the spinalis and the iliocostalis, are shown The spine of the scapula is noted at the level of the third rib The posterior intercostal muscle is omitted in this space to show the pleura and the intercostal vessels and nerve

Finally, in Figure E, other muscles are added on the right side and completed on the left side, where the outline of the trapezius marks the most superficial layer of the musculature It should be remarked that the dorsal spines and laminae are less deeply placed than those in the lumbar or the cervical region

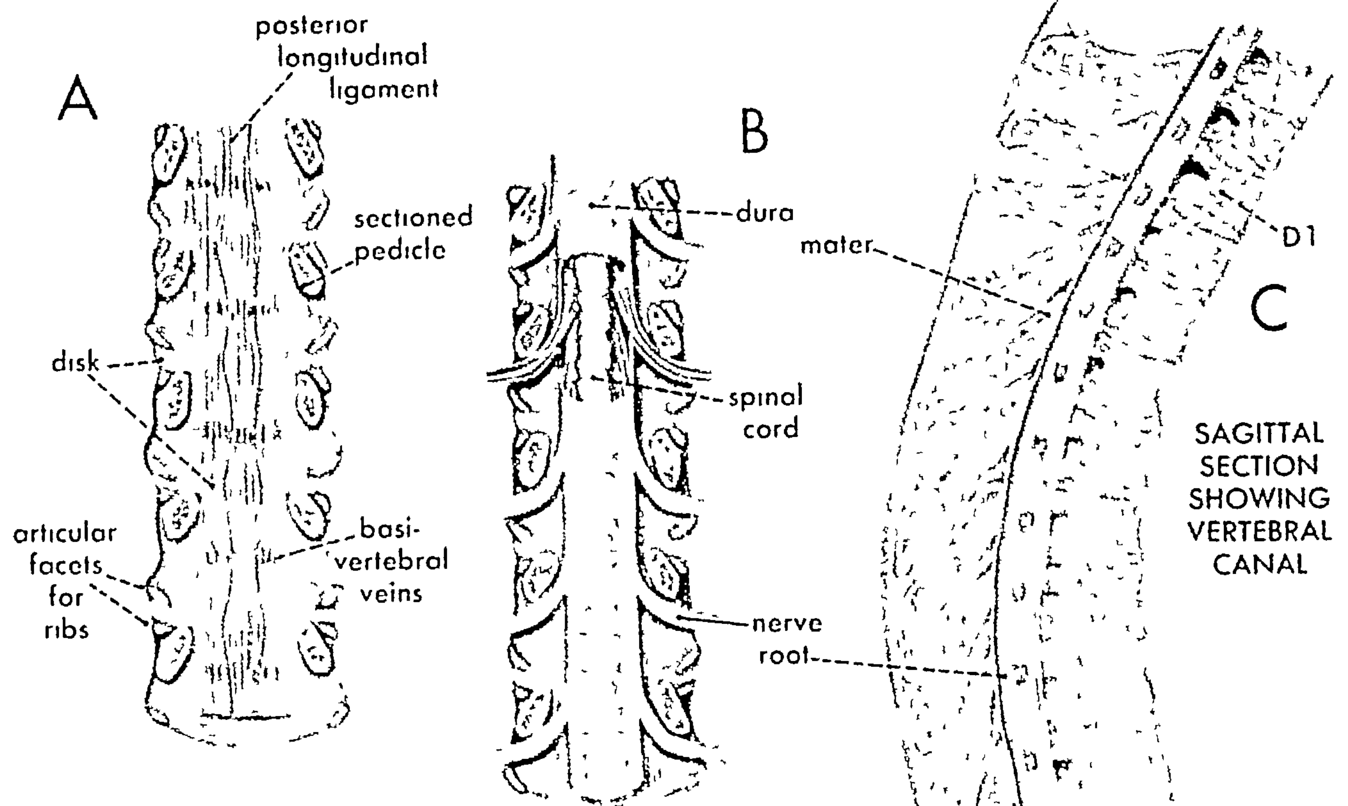

A
posterior
longitudinal
ligament
sectioned
pedicle
disk
articular
facets
for
ribs
basi-
vertebral
veins
B
dura
spinal
cord
nerve
root
mater
D1
C
SAGITTAL
SECTION
SHOWING
VERTEBRAL
CANAL
D12
D
intercostal
vessels & nerve
costo-
transverse
ligaments
pleura
third rib
spine of
scapula
intercostal
muscle
D3
vertebral
border
E
rhomboids
splenii
outline of
trapezius
D1
levator
costae
serratus
posterior
superior
inferior
longissimus
posterior
ramus
spinalis
iliocostalis
rotatores
muscles
latissimus
dorsi
D12

PLATE 43

Posterior Exposures of the Dorsal Vertebrae

The drawings on this plate serve to apply the anatomic knowledge detailed on Plate 42 to the exposure of the laminae, the facet articulations and the medial portions of the ribs At this point it should be remarked that the paravertebral muscles contain a considerable amount of dense aponeurotic tissue which prevents wide retraction In these drawings, however, for diagrammatic purposes the wounds have been shortened and the extent of retraction has been exaggerated

Exposure of the laminae is often required for spinal fusion in this region The indications may be instability following fracture or fracture-dislocation, a focus of tuberculous osteitis, or scoliosis or other deformity of paralytic or idiopathic nature Laminectomy will enable the surgeon to explore the vertebral canal for lesions involving the spinal cord, the nerve roots or the spinal membranes Partial laminectomy may be indicated for disk prolapse, which, however, is uncommon in the dorsal region Finally, costotransversectomy is utilized for the drainage of the mediastinal abscess arising from tuberculous involvement of the adjacent vertebral bodies

The incision is midline (Fig B), and, depending on the breadth of exposure required, is best made of length extending one or two spines above and below the laminae approached

Figures A and C are complementary Figure A shows in cross section the paravertebral muscles retracted bilaterally, baring the spinous processes and laminae as far laterally as the costotransverse articulations Figure C illustrates the exposure of the laminae of D 6, 7 and 8 after subperiosteal reflection of the soft tissues The muscles are retracted more widely in these drawings than is usual in operative procedures to demonstrate the positions of the facet and the costotransverse articulations The dotted lines depict the position of section for complete and partial laminectomies Complete laminectomy involving one or more arches would be required for exploration of the vertebral canal and its contents Partial laminectomy, when employed for disk prolapse, must be carried as far laterally as possible

Figures D and E show the unilateral exposure of laminae and the medial portion of the eighth rib Note the line of section of the transverse process and rib for costotransversectomy This procedure is employed to drain a mediastinal abscess arising from tuberculous disease of the vertebral bodies A catheter can be left *in situ* and local instillation of antibiotics utilized, as is increasingly the practice in such cases

In the cross sections A and D, attention should be focused on the relation of the pleural cavity, the lungs, the aorta, the azygos vein and the esophagus to the vertebrae

retracted
paravertebral
muscles
spinous
process
rib
intercostal
vessels
transverse
process
D8
parietal
pleura
A
EXPOSURE
OF
LAMINAE
azygos
vein
aorta
esophagus
D1
D12
B
MIDLINE
INCISION
C
EXPOSURE
OF LAMINAE
D6, 7, 8
line
of
complete
laminectomy
line
of
partial
laminectomy
facet
articulations
lines
of
section
of rib &
transverse
process
eighth rib
lamina
D8
E
D8
mediastinal
abscess
D
EXPOSURE
FOR
COSTOTRANSVERSECTOMY

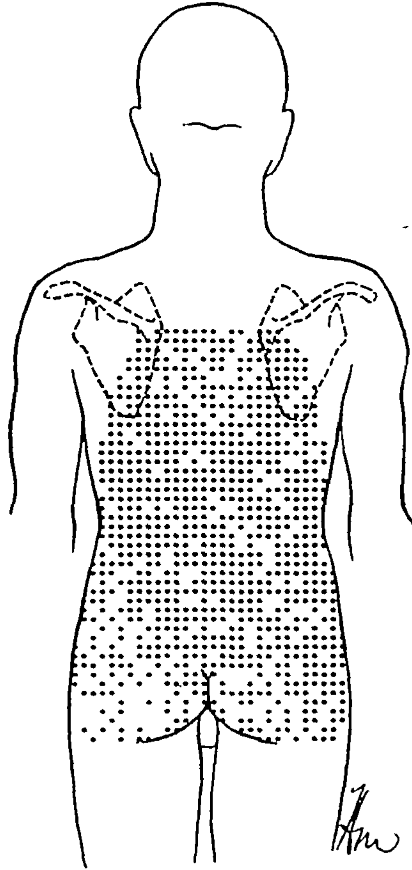


FIG 39 Area of skin preparation for operative procedures on the lumbosacral spine

The area of skin preparation extends from the spines of the scapulae to the gluteal folds

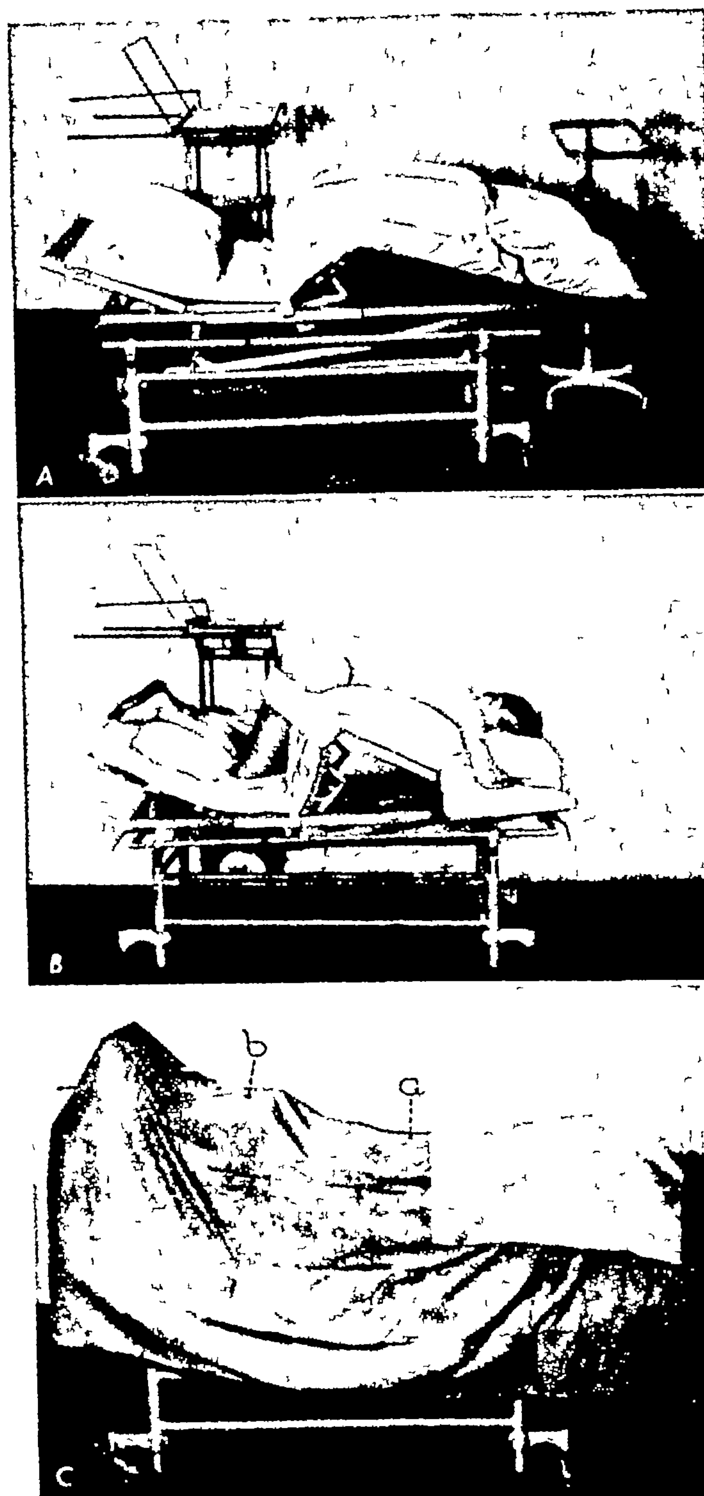


FIG 40 Lumbar exposure Posturing and draping
(A) Table arranged with panels flexed
(B) Patient in position Note pillow for head, elbow pads, shoulder-hip pads, and pillow under lower legs and feet Iliac crest is indicated Note relationship of iliac crest to table break.
(C) Patient draped for lumbar discoidectomy or fusion (a) Operative area; (b) instrument tray.

Plate 45

Posterior Exposure of the Lower Lumbar and the Upper Sacral Vertebrae

It has previously been stated that the laminae of the lower lumbar vertebrae are deeply placed because of the massive size of the paravertebral muscles To facilitate operative exposure, the depth of the wound is diminished by posturing the patient so as to minimize the lumbar lordosis

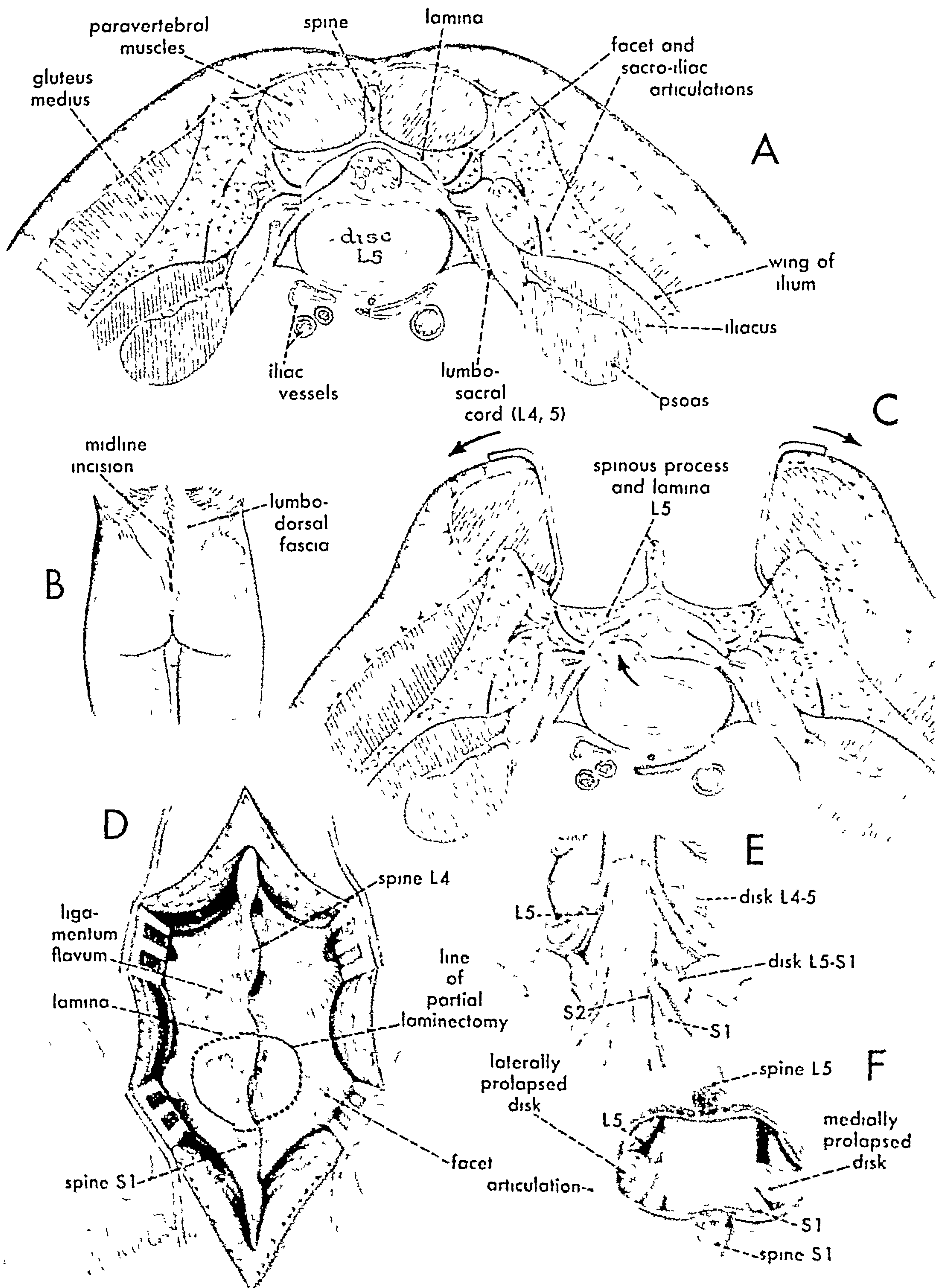
The lumbosacral junction is the area of the vertebral column most frequently exposed, as it is the region most prone to degenerative disease of the intervertebral disks and also to disk injury from sudden effort Besides, developmental abnormalities appear to predispose to painful syndromes, for which lumbosacral arthrodesis by bone graft has been a common form of treatment The two most commonly performed groups of surgical procedures are, therefore, for disk removal at the L 4-5 and L 5-S 1 levels and lumbosacral fusion Laminectomy with exploration of the vertebral canal may be required for neoplastic lesions involving the cauda equina or the meninges

In Figure A, the viewer is looking caudad at a cross section at the level of the L 5 disk Note the lumbosacral cord, L 4 and 5, crossing the ala of the sacrum on each side The anterior relationship of the iliac vessels and, cephalad, of the aorta and the inferior vena cava should be remarked, because perforation of these vascular channels has been reported as a complication of curettage of the disk spaces

Figure A should be correlated with Figure C, which shows the paravertebral muscles reflected subperiosteally and retracted, a midline incision (Fig B) having been utilized Figure D illustrates the routine operative exposure obtained after the soft tissues are reflected from the spines and the laminae as far laterally as the facet articulations The line of section for partial laminectomy for resection of the prolapsed disk is indicated When unilateral exposure is required, section need not extend beyond the midline The lines for complete laminectomy are as indicated in Plate 43

Insets E and F detail the relationship of the disks at L 4-5 and L 5-S 1 levels to the fifth lumbar and the first and the second sacral nerve roots The prolapsed disk, also shown in Figure C, can compress the fifth lumbar root far laterally When prolapsed medially, it may compress the first sacral nerve directly or the second sacral nerve while still contained within the dural sac A hypothetical case presenting both the lateral and the medial sites of prolapse is represented in Figures E and F

Figure D depicts the exposure required for lumbosacral fusion by twin, H, or other type of bone graft The drawings on these two plates can be utilized further to plan other operative procedures as required



A
paravertebral muscles
spine
lamina
facet and sacro-iliac articulations
gluteus medius
disc L5
wing of ilium
iliacus
iliac vessels
lumbo-sacral cord (L4, 5)
psoas
B
midline incision
lumbo-dorsal fascia
C
spinous process and lamina L5
D
spine L4
liga-mentum flavum
lamina
line of partial laminectomy
facet articulation
spine S1
E
disk L4-5
L5
disk L5-S1
S2
S1
F
laterally prolapsed disk
spine L5
L5
medially prolapsed disk
S1
spine S1

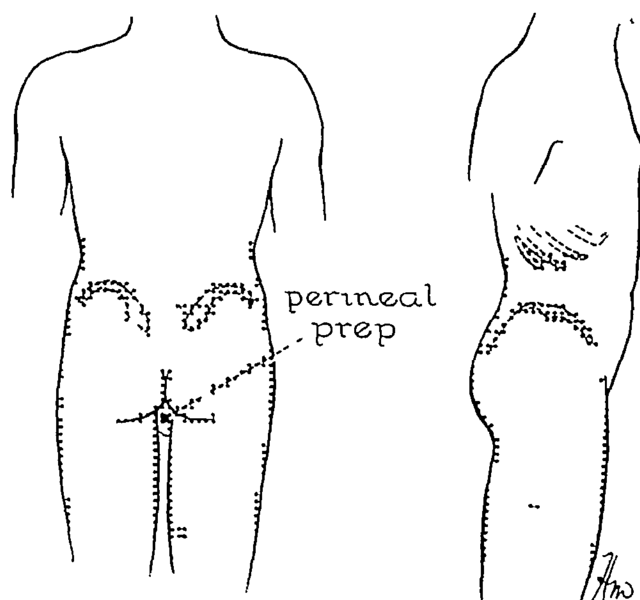


FIG 41 Area of skin preparation for operative procedures on the sacrum, the coccyx, the posterior iliac crest and the sacro-iliac joint

These drawings represent composites of the area required The area corresponds to the bathing drawer area and includes a careful preparation of the perineal area in the case of operations on the lower sacrum and coccyx

In the case of unilateral procedures on the posterior iliac crest or the sacro-iliac region, the area can be delimited to the side required

Fig 42 Sacrum, coccyx, posterior iliac crest and sacro-iliac joint Posturing and draping

(A) Patient postured Note arrangement of pillow for head, elbow rests, shoulder-hip pads over table break, and pillow under legs By varying the break in the table and the relationship of the patient to the break, the area for operation can be made most prominent

(B) Draping completed for exposure of upper sacrum, iliac crest or sacro-iliac joint If necessary, the table can be tilted to one side or the other as required to facilitate access to the sacro-iliac joint (a) Operative site, (b) instrument tray

(C) Draping completed for resection of the coccyx (a) Operative site; (b) instrument tray

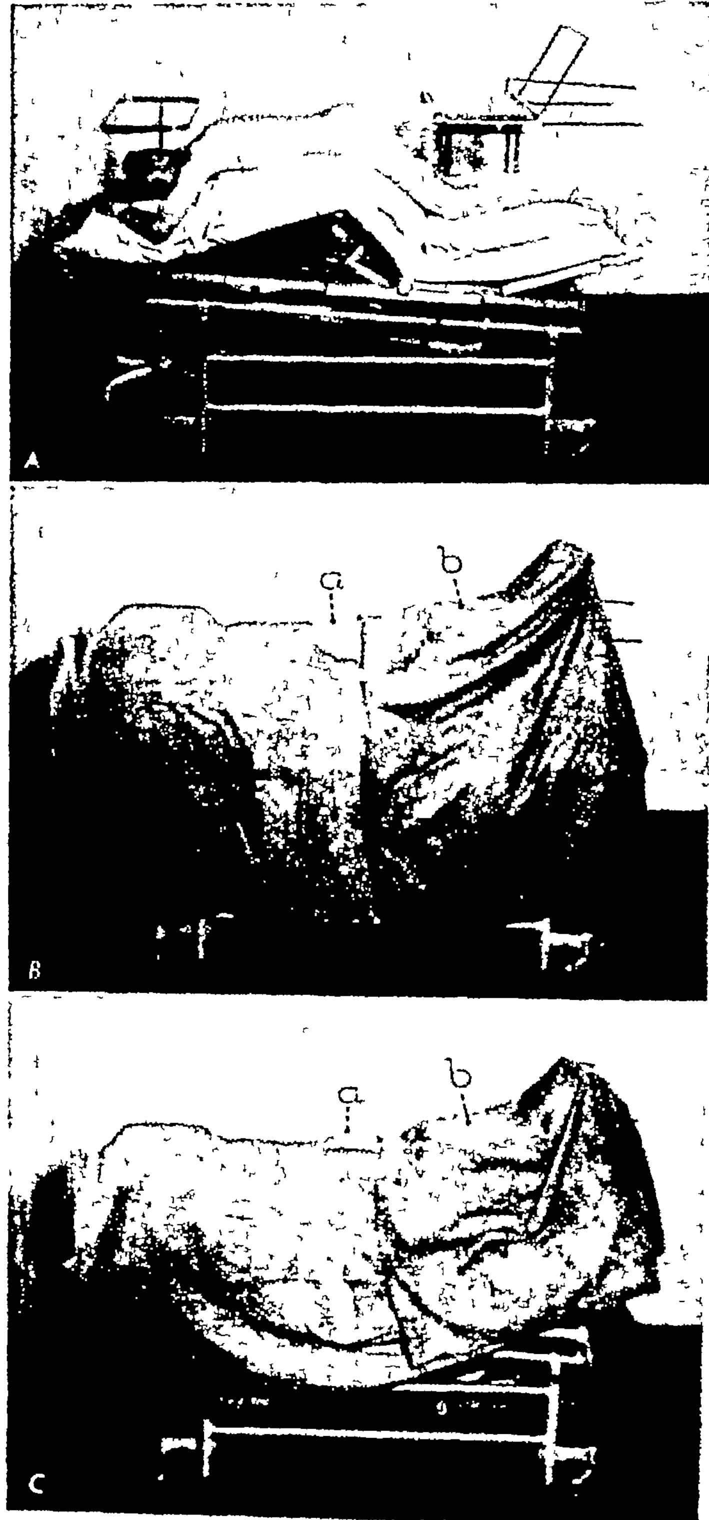


PLATE 46

Relations of the Sacrum and the Coccyx

The drawings on this plate and Plate 47 illustrate the anatomic structures of surgical significance related to the sacrum and the coccyx Correlation should also be made with Plate 50

These drawings will be useful to the surgeon when performing coccygectomy for traumatic coccydynia or when exposing the lower sacrum and coccyx for neoplasm, such as chondroma or chordoma The knowledge depicted will also assist in understanding the surgical anatomy in operative procedures undertaken for postanal dermoids and in resection of the lower sacrum and coccyx for malignant neoplasms of the lower rectum which have infiltrated posteriorly

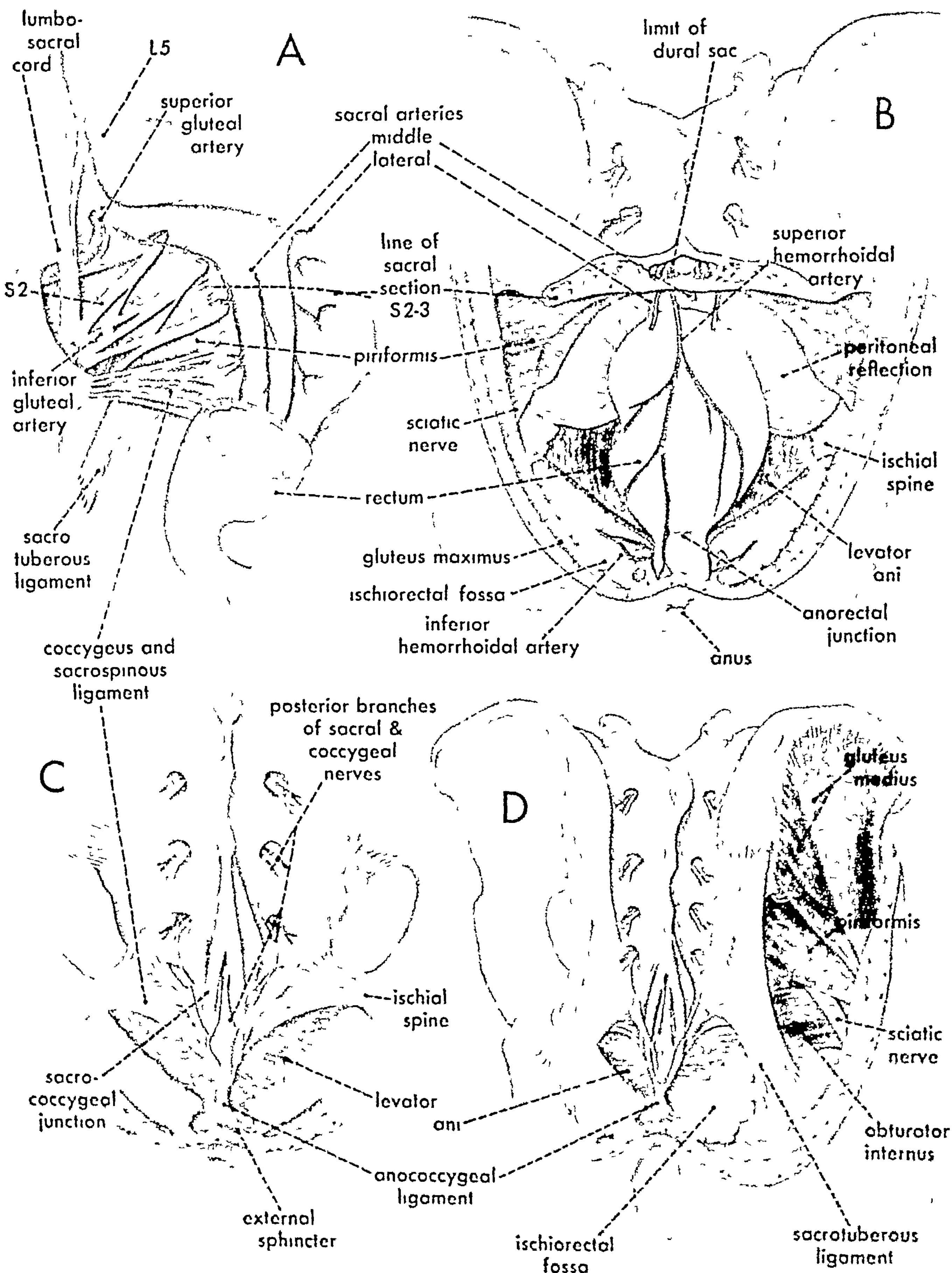
Figures A and B stress the important anterior relations In A, the sacrum and the coccyx are viewed from within the pelvis Note especially the lumbosacral plexus and the formation of the sciatic nerve This massive nerve, the largest in the body, passes through the greater sciatic notch anterior to the piriformis muscle, at whose lower border it is seen in Plate 50 D The lateral sacral, a branch of the superior gluteal artery, passes downward medial to the sacral foramina This paired artery and the middle sacral artery are sectioned in ablation of the lower sacrum or coccyx, and knowledge of their position facilitates hemostasis

The rectum and the anus are shown in Figures A and B and again in Figure B on Plate 47 In Figure B, the sacrum and the coccyx have been removed along the lines of section between S 2 and 3 to show the anterior visceral relations The large ampulla of the rectum leading into the recto-anal junction and the anal canal is seen Note the superior hemorrhoidal vessels on its posterior surface and the inferior hemorrhoidal vessels crossing the ischiorectal fossa to the region of the anal orifice The peritoneal reflection should be studied especially, but this is more important for general surgical procedures such as abdominoperineal resection of the rectum The peritoneum passes down, surrounding the sigmoid colon to the level of S 3 At this point the rectum begins and the peritoneum covers only its anterior and lateral aspects, forming thus the posterior wall of the rectovesical pouch in the male or the pouch of Douglas in the female This relationship is well shown in the corresponding Figures B in this plate and Plate 47 The proximity of the sciatic nerve is not usually realized, but it can be studied in A, B and D This proximity explains the sciatic pain present in infiltrating neoplasms arising from the adjacent bones or from the rectum

In Figures C and D, the addition of the soft parts to the posterior aspect of the sacrum and the coccyx is initiated, and this build-up is completed in Figure A on Plate 47

The sacrospinous ligament, which bounds the coccygeus muscle posteriorly, inserts into the lateral border of the lower sacrum and coccyx (Fig C) The levator ani forming the pelvic floor is inserted into the coccyx to its tip This pelvic diaphragm surrounds the recto-anal junction, reinforcing the valve-like action of the internal sphincteric mechanism From the tip of the coccyx the anococcygeal ligament (body) extends in the median plane to fuse with the external sphincter of the anus and adjacent soft tissues

Figure D shows the addition of the sacrotuberous ligament The posterior branches of the sacrococcygeal nerves are depicted Their injury accounts in part for the neuralgic pain in coccydynia The gluteus medius, the piriformis and the obturator internus are shown on the right side of this drawing Note the ischial tuberosity as a localizing landmark and also the sciatic nerve in its relation to this tuberosity and the above-mentioned muscles



A
B
C
D
lumbo-sacral cord
L5
superior gluteal artery
sacral arteries middle lateral
limit of dural sac
line of sacral section S2-3
S2
superior hemorrhoidal artery
piriformis
peritoneal reflection
inferior gluteal artery
sciatic nerve
ischial spine
rectum
sacro tuberous ligament
levator ani
gluteus maximus
ischiorectal fossa
inferior hemorrhoidal artery
anorectal junction
anus
coccygeus and sacrospinous ligament
posterior branches of sacral & coccygeal nerves
gluteus medius
piriformis
ischial spine
sciatic nerve
sacro-coccygeal junction
levator ani
obturator internus
anococcygeal ligament
external sphincter
ischiorectal fossa
sacrotuberous ligament

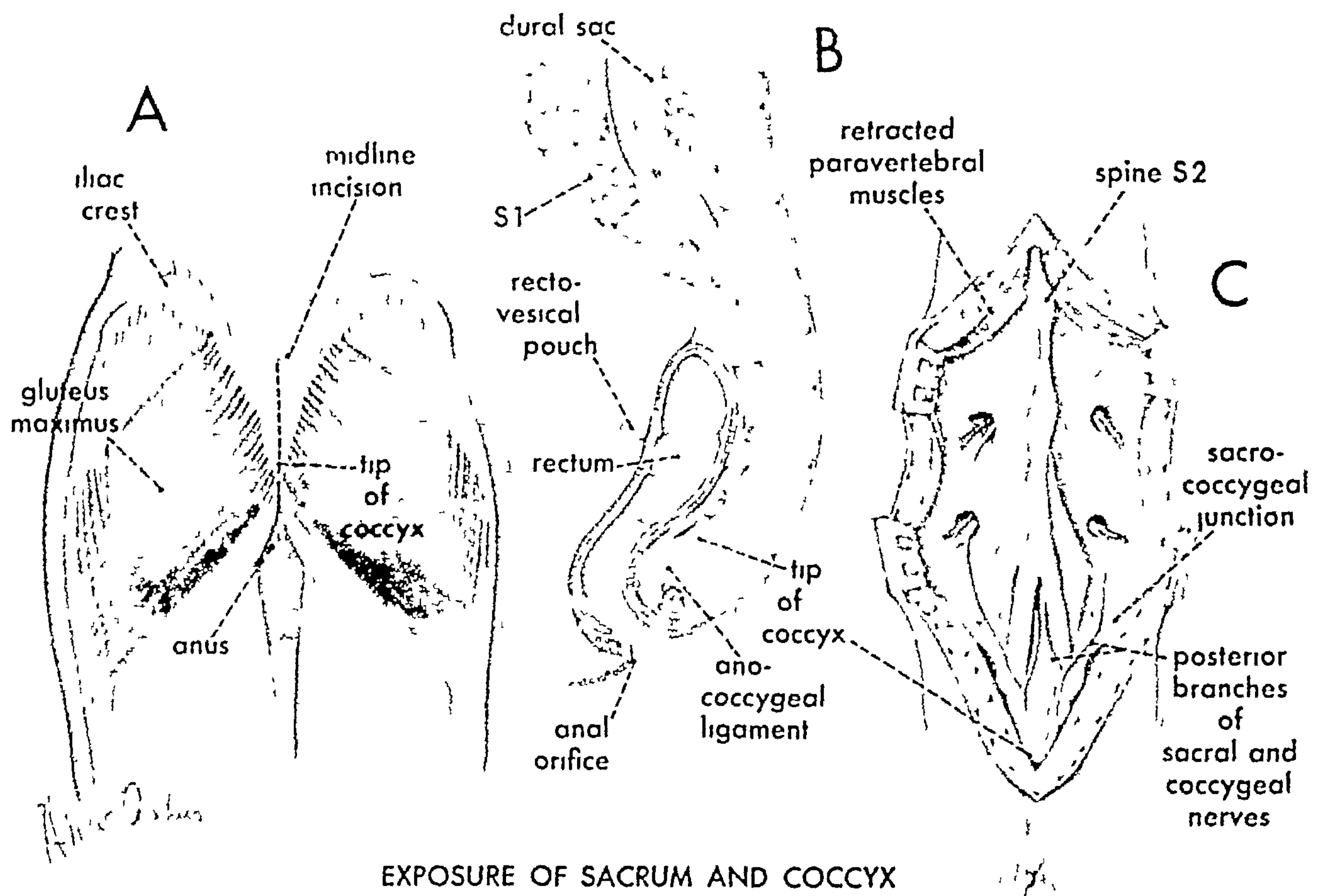
PLATE 47

Posterior Exposure of the Sacrum and the Coccyx

The drawings on this plate continue the exposition of those on Plate 46 Figure A shows the addition of the soft tissues completed The midline incision usually employed for the posterior exposure is indicated Only the lower portion of this incision is required for coccygectomy, and some surgeons prefer a transverse incision to remove as remotely as possible the section of soft tissues from the anal orifice and perianal skin

In Figure B, two important relationships are represented (1) The lower limit of the dural sac extending just below the disk between S 2 and 3, and (2) the level of the peritoneal reflection on the rectum, which is indicated just inferior to S 3 Note also the close proximity of the rectum and the anus to the anterior concavity of the sacrum and the coccyx

Figure C shows the subperiosteal reflection of the soft tissues and the exposure of the posterior surface of the sacrum and the coccyx With the knowledge gained from the preceding drawings, operative procedures can be planned and carried out as required



EXPOSURE OF SACRUM AND COCCYX

Plate 48

Relations and Exposure of the Sacro-iliac Joint

This plate combines the important anatomic relations of the sacro-iliac joint with its exposure applied for arthrodesis by the Smith-Petersen technic

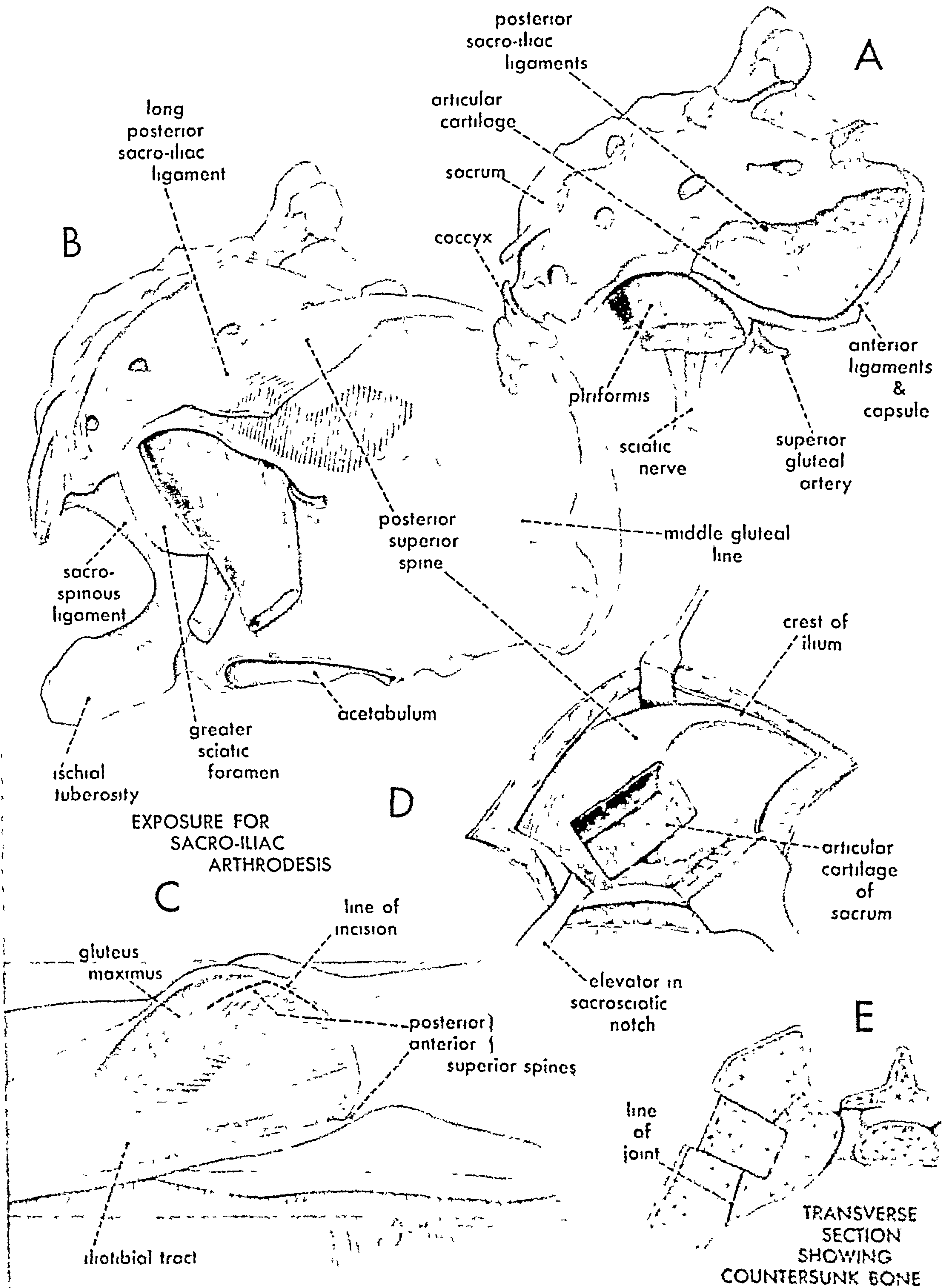
Present-day knowledge of the lumbar disk lesions has clarified the underlying mechanism of some of the pain syndromes formerly attributed to strain, subluxation or traumatic arthritis of this joint. Sacro-iliac arthrodesis is, therefore, less frequently performed for these disorders and is reserved for chronic subluxation following fracture-dislocation of the pelvis and for tuberculous disease The same exposure is utilized for neoplasms in this region, of which the most common are chondromata and sarcomata

Figures A and B have been carefully reproduced from specimens and roentgenograms on which the articular surface of the sacrum has been studied by means of radiopaque media for visualization on the surface of the ilium as seen at operation Note that the joint space lies opposite the posterior superior spine, extending upward and forward from the rim of the sacrosciatic notch The important structures in the greater sacrosciatic foramen are the piriformis muscle, below which the sciatic nerve emerges to pass downward (see Plate 50), and the superior gluteal vessels, which pass forward above the piriformis along the middle gluteal line These vessels may be severed in subperiosteal reflection of the gluteal muscles for exposure of the ilium over the joint

Figures C, D and E show the exposure of the outer table of the ilium over the sacro-iliac joint Through this approach a block of ilium may be resected, and, after the cartilaginous surfaces have been ablated, the block can be countersunk in order to secure arthrodesis, as has been described by Smith-Petersen

Figure C shows the position of the patient and the curved line of incision centered on the posterior superior spine The upper limb follows the iliac crest forward, while the lower limb curves downward and forward The superior portion of the incision is deepened to the iliac crest and the soft tissues are reflected subperiosteally to expose the posterior portion of the crest and the outer table of the ilium Once the deep plane is secured, the lower portion of the incision is deepened by section of the gluteus maximus in the direction of its fibers The rim of the sacrosciatic notch is located with an elevator, and the further exposure is carried out as shown in D If possible, the superior gluteal vessels are avoided by limiting the extent of the exposure downward in this area

Figures D and E depict the application of this approach to the Smith-Petersen arthrodesis A block of bone, roughly 1¼ by 1¾ inches, is resected The inferior border of this rectangle should be just above the rim of the notch Its posterior border should pass upward and forward just anterior to the posterior superior spine The ilium, from ¾ to 1 inch thick at some points, is best removed with chisel or rotatory saw The thin cartilage is removed from both joint surfaces and the block is countersunk, as shown in cross section E


A
posterior sacro-iliac ligaments
articular cartilage
sacrum
coccyx
piriformis
sciatic nerve
superior gluteal artery
anterior ligaments & capsule
B
long posterior sacro-iliac ligament
posterior superior spine
middle gluteal line
sacro-spinous ligament
ischial tuberosity
greater sciatic foramen
acetabulum
EXPOSURE FOR SACRO-ILIAC ARTHRODESIS
C
gluteus maximus
line of incision
posterior
anterior
superior spines
iliotibial tract
D
crest of ilium
articular cartilage of sacrum
elevator in sacrosciatic notch
E
line of joint
TRANSVERSE SECTION SHOWING COUNTERSUNK BONE

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Films

1 Combined Operation Fusion of Lumbo-sacral Joint and Hemilaminectomy for Removal of Herniated Disk (1942) (By G Edmund Haggart, M D, James L Poppen, M D, and James W Toumey, M D, Boston)

2 reels, 16 mm, silent.

Procurable from Davis & Geck, Inc, 1 Casper St, Danbury, Conn

2 Protruded Intervertebral Disk (diagnosis and surgical treatment) (1943)

2 reels, 16 mm, silent color

Procurable from J Grafton Love, M D, Rochester, Minn

3 Sciatic Pain Caused by Ruptured Intervertebral Disk (1942) (By Guy A Caldwell, M D, and Dean H Echols, M D, New Orleans)

1½ reels, 16 mm, silent color

Procurable from Alton Oschner Medical Foundation, 3503 Prytania St, New Orleans 15, La

4 Modified Double Notched Graft Lumbosacral Spinal Fusion (1946) (By Alfons Altenberg, M D, Monroe and Guy A Caldwell, M D, New Orleans)

1½ reels, 16 mm, silent color

Procurable from Alton Oschner Medical Foundation, 3503 Prytania St, New Orleans 15, La

5 Spinal Fusion with Osteoperiosteal Graft (1941) (By Paul E McMaster, M D, Beverly Hills)

1 reel, 16 mm, silent color

Procurable from E R Squibb & Sons, 745 Fifth Ave, New York 22, N Y

6 Lumbosacral Spinal Fusion with Metallic Plate Fixation (illustrates a modified Hibbs technic of spinal fusion, plus internal fixation with a metallic plate) (1952) (By Philip D Wilson, M D, and L Ramsay Straub, M D, New York)

1½ reels, 16 mm, sound color

Procurable from Sturgis-Grant Productions Inc, 314 E 46th St, New York 17, N Y

7 Surgical Approaches to the Joints of the Spine and Sacroiliac (1952) (By LeRoy C Abbott, M D, Donald C Smith, M D, and J B de C M Saunders, M B, San Francisco)

2½ reels, 16 mm, sound color

Procurable from Central Office Film Library, Veterans Administration, Vermont Ave and H St, N W, Washington 25, D C

11 TO 16

THE LOWER EXTREMITY

II

THE HIP

The *hip joint* is the most deeply situated articulation in the human body It is of the ball-and-socket universal type and is organized for stability and movement The roof of the acetabulum and the upper portion of the head and the neck of the femur transmit the body weight to the lower limb while affording motion at the junction of the trunk and the inferior extremity The acetabulum is, therefore, a deep socket, the capsular ligaments are strong, and the surrounding muscles are large and powerful For these reasons, access to the joint cavity is secured only by a major surgical procedure

The greater trochanter and the upper femoral shaft are most superficially placed, and therefore most readily accessible, from the lateral aspect The head and the neck are most easily reached laterally and superiorly, anteriorly or posteriorly, in that order The various exposures have evolved round these anatomic considerations and consist of a lateral incision from the tip of the trochanter downward in the axis of the femur, with a branch extending forward, upward or backward, to follow the various muscle planes, as will be seen in the following illustrations

The evolution of the various approaches is well described in the early paper by Brackett and supplemented by the selected references cited at the close of the chapter Although individual preferences and modifications abound, the three standard exposures are The *lateral* for subcapital, transcervical, intertrochanteric and subtrochanteric fractures, the *posterolateral,* developed by Gibson from those of Langenbeck and Kocher, at present accepted as most generally useful for the operative reduction of congenital dislocations and acquired fracture-dislocations, for reconstructive procedures, including the replacement prostheses for the femoral head and mold arthroplasties, and for exposure of the sciatic nerve in the buttock, and, finally, the *anterolateral* exposure, developed by Smith-Petersen from those of Bardenhauer, Sprengel and Hueter, a more formidable undertaking second in choice for the above operations and often preferred for intra-articular and extra-articular arthrodesis of the joint.

PLATE 49

Anterior Relations of the Hip Joint

This plate illustrates the important anatomic structures which are related to the anterior aspect of the joint The soft tissues are added to the skeletal framework formed by the upper end of the femur articulating with the acetabulum in four successive steps

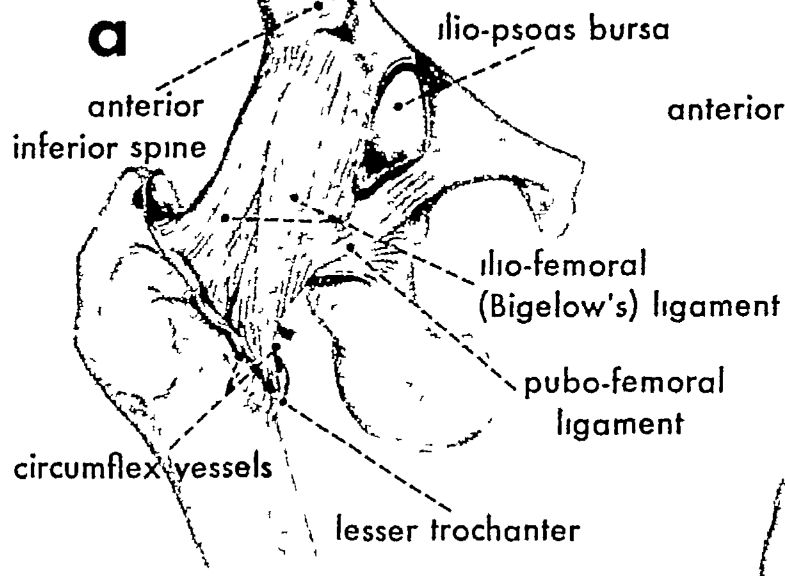
In a, the inverted Y-shaped ligament of Bigelow is seen arising from the anterior inferior spine and spreading out to insert the full length of the intertrochanteric line This is the strongest ligament in the body, and it will be remembered that it acts as a pivot round which the femoral head rotates into the various positions of dislocation The lateral femoral circumflex artery is shown in its relation to the capsule Penetrating branches pierce the capsule and run along the neck in the cervical ligaments to supply the osseous tissue of the neck and the head The iliopsoas bursa is also seen This synovial sac may communicate with the joint cavity

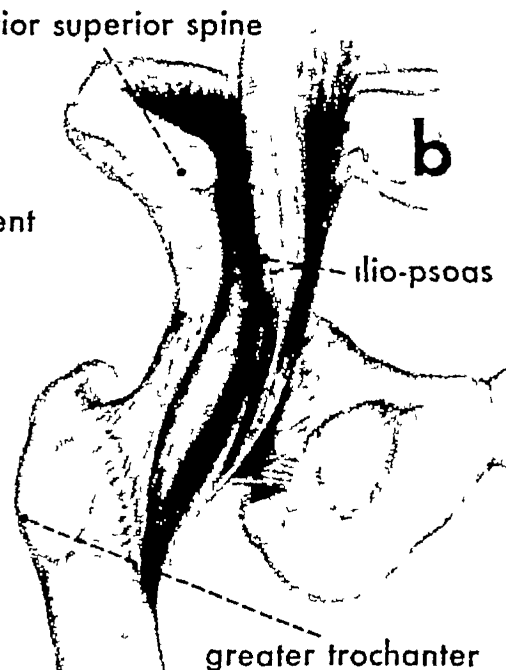
In b, the iliopsoas muscle has been added, and it is seen wrapping itself round the iliofemoral and the pubofemoral ligaments to be inserted into the lesser trochanter and the shaft of the femur

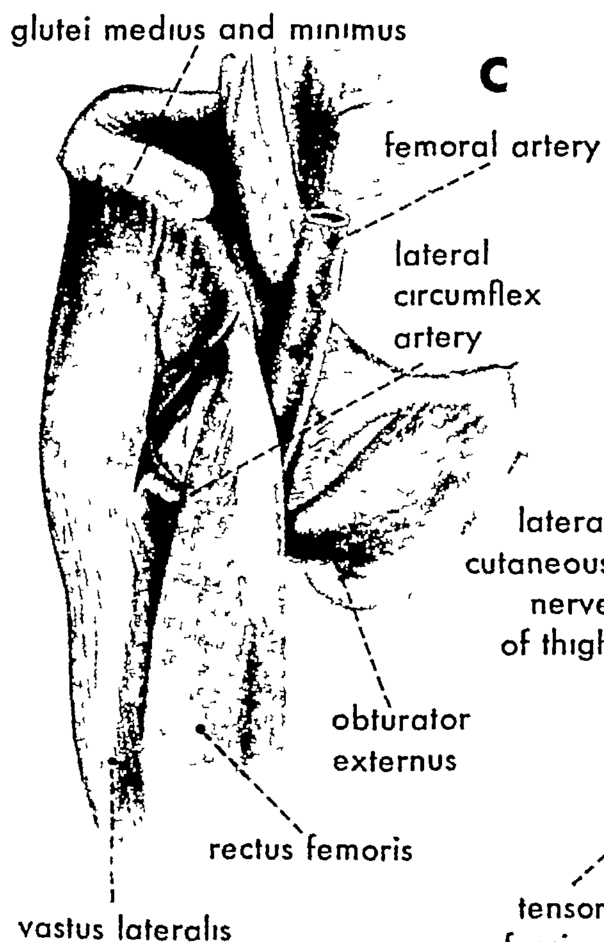
Figure c shows the femoral artery, which lies directly on the iliopsoas, and this vessel and the other elements of the neurovascular bundle shown in d constitute the most important structures anterior to the hip joint. The rectus femoris, arising from the anterior inferior iliac spine to cover the lateral portion of Bigelow's ligament, and the vastus lateralis, arising just below the greater trochanter, extend downward to cover the anterior and the lateral aspects of the femoral shaft. The glutei medius and minimus are seen covering the ilium and bounding the hip joint on its superior aspect Between this muscle and the rectus femoris course the lateral femoral circumflex vessels, branches of which are usually severed in the iliofemoral exposure of the joint

In d, the neurovascular bundle and the remaining muscles are added Special attention should be paid to the fascial plane between the tensor fasciae latae and the sartorius muscles which marks the cleft through which the iliofemoral exposure is made This is crossed superficially by the lateral cutaneous nerve of the thigh

(Moseley, H F An Atlas of Surgical Exposures, North Chicago, Abbott)


a
ilio-psoas bursa
anterior inferior spine
ilio-femoral (Bigelow's) ligament
pubo-femoral ligament
circumflex vessels
lesser trochanter


anterior superior spine
b
ilio-psoas
greater trochanter


glutei medius and minimus
c
femoral artery
lateral circumflex artery
obturator externus
rectus femoris
vastus lateralis

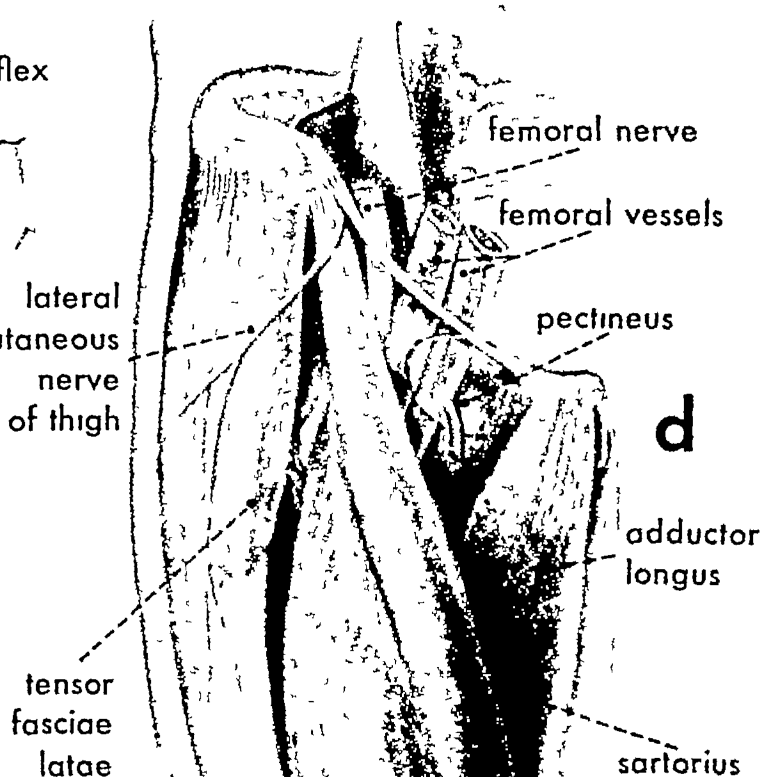

femoral nerve
femoral vessels
pectineus
lateral cutaneous nerve of thigh
d
adductor longus
tensor fasciae latae
sartorius

PLATE 50

Posterior Relations of the Hip Joint

In this plate, the soft tissues have been superimposed on the skeletal framework in five successive steps

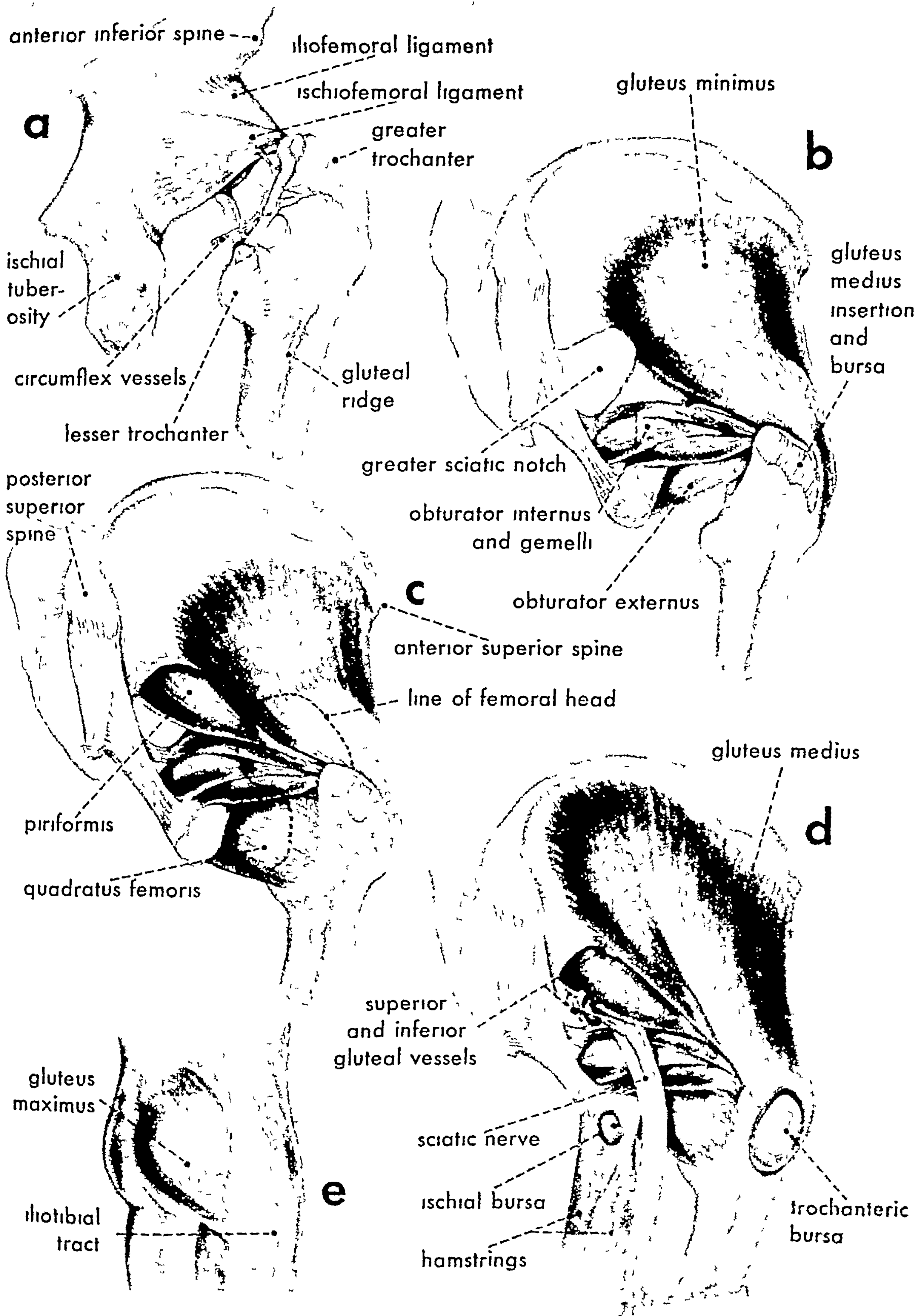
In a, the posterior capsule is strengthened by the ischiofemoral ligament, which inserts on the superior portion of the intertrochanteric ridge The synovial membrane pouches beyond the capsule in this area The most important vascular supply to the femoral head is through the branches of the medial femoral circumflex artery, which sends posterosuperior and postero-inferior groups of vessels along the neck to enter the head Injury to these vessels is the usual cause of aseptic necrosis and subsequent traumatic arthritis involving the femoral head

In b, the first layer of muscles, including the gluteus minimus and the external rotators, obturator internus and gemelli and obturator externus, is added This layer of muscles is completed in c, which shows the piriformis leaving the great sciatic notch and also the quadratus femoris This completed layer forms the muscular plane through which the head displaces in posterior dislocation. It also forms the bed on which the sciatic nerve rests and constitutes a protective barrier to this important structure in dislocations of the joint

The gluteus medius is illustrated in d, together with the trochanteric bursa occasionally involved in calcified deposits and tuberculous disease The sciatic notch, with the piriformis muscle separating the superior gluteal vessels and nerves from the inferior gluteal vessels and the sciatic nerve, is seen The ischial tuberosity with the origin of the hamstrings and the associated bursa are noted

Finally, the gluteus maximus, the iliotibial tract and the tensor fasciae latae are added in e These constitute the superficial layer of musculature corresponding to the deltoid mass in the shoulder region It will be seen that this layer can be sectioned readily through aponeurotic tissue just anterior to the anterior border of the gluteus maximus and down the iliotibial tract, as in the posterolateral exposure of the joint

(Moseley, H F An Atlas of Surgical Exposures, North Chicago, Abbott)



a
anterior inferior spine
iliofemoral ligament
ischiofemoral ligament
greater trochanter
ischial tuber-osity
circumflex vessels
lesser trochanter
gluteal ridge
b
gluteus minimus
gluteus medius insertion and bursa
greater sciatic notch
obturator internus and gemelli
obturator externus
c
posterior superior spine
anterior superior spine
line of femoral head
piriformis
quadratus femoris
d
gluteus medius
superior and inferior gluteal vessels
sciatic nerve
ischial bursa
hamstrings
trochanteric bursa
e
gluteus maximus
iliotibial tract

Plate 51

The Arterial Supply to the Upper End of the Femur

The surgeon exposing the hip for disorders caused by injury or disease must ever bear in mind the importance of the circulation to the head and the neck of the femur This assumes greatest significance in traumatic derangements such as fractures and dislocations, in which the initial injury or the subsequent operative procedure or the combination of both factors may so interfere with the circulation by division or thrombosis that the head is deprived of vascularity Aseptic necrosis with collapse of the head follows, and destruction of the joint is the inevitable conclusion

This plate summarizes the work of Tucker, which corroborates the views of Sir Astley Cooper, of the last century, and those of other investigators, such as Wolcott, on this subject

The arterial supply to the head and the neck of the femur is derived from three sources

1 The retinacular vessels, which arise from the medial and the lateral femoral circumflex arteries and run along the neck under the synovial folds in the ligaments of Weitbrecht and Stanley

2 The foveolar vessels, originating from the obturator and running in the ligamentum teres

3 The ascending branches of the nutrient artery of the femur

The important question has always been the relative importance of these three sets of vessels in the supply of the head itself, and from this the deduction which vessels, when occluded, cause aseptic necrosis

Present knowledge may be summarized as follows

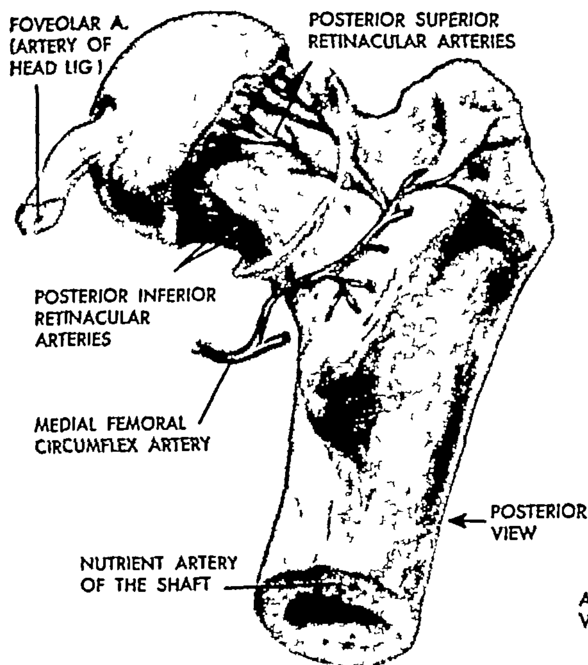
1 There is a difference in the relative significance of these sources in the young when compared with the adult subject The foveolar circulation increas with age, and anastomosis between the foveolar ai the retinacular vessels is the rule after the epiphy of the head unites with the neck This accounts f the much greater susceptibility of the young to asept necrosis—for example, Perthes' disease, aseptic n crosis after manipulation for congenital dislocatior slipped epiphysis, and after fractures of the neck ai traumatic dislocations

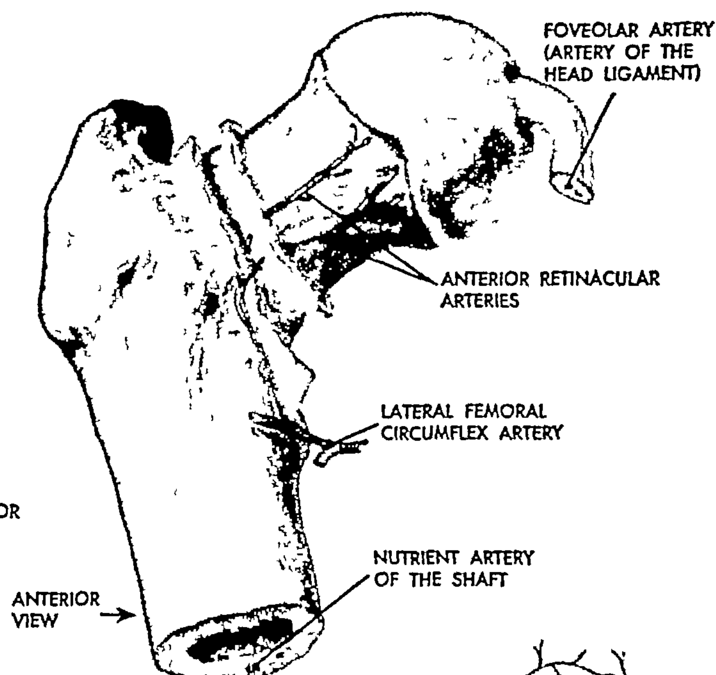
2 The retinacular vessels afford the chief supp to the head There are three groups of thes (a) Posterosuperior, (b) postero-inferior, (c) a terior Of these three groups, the posterosuperior the largest and the most important The retinacul vessels supply the ossifying center of the head Th are loosely attached to the neck laterally, but becon more fixed toward the area of the epiphyseal plat They do not run in the capsule, but are close attached to the bone Derangement of these vess is the chief cause of aseptic necrosis Fractures of tl femoral neck caused by sudden external rotati usually leave the posterior vessels intact in the sol tissue hinge With the vertical-type fracture line ar displacement, this soft-tissue hinge is often disrupte with consequent occlusion of the capital circulatio

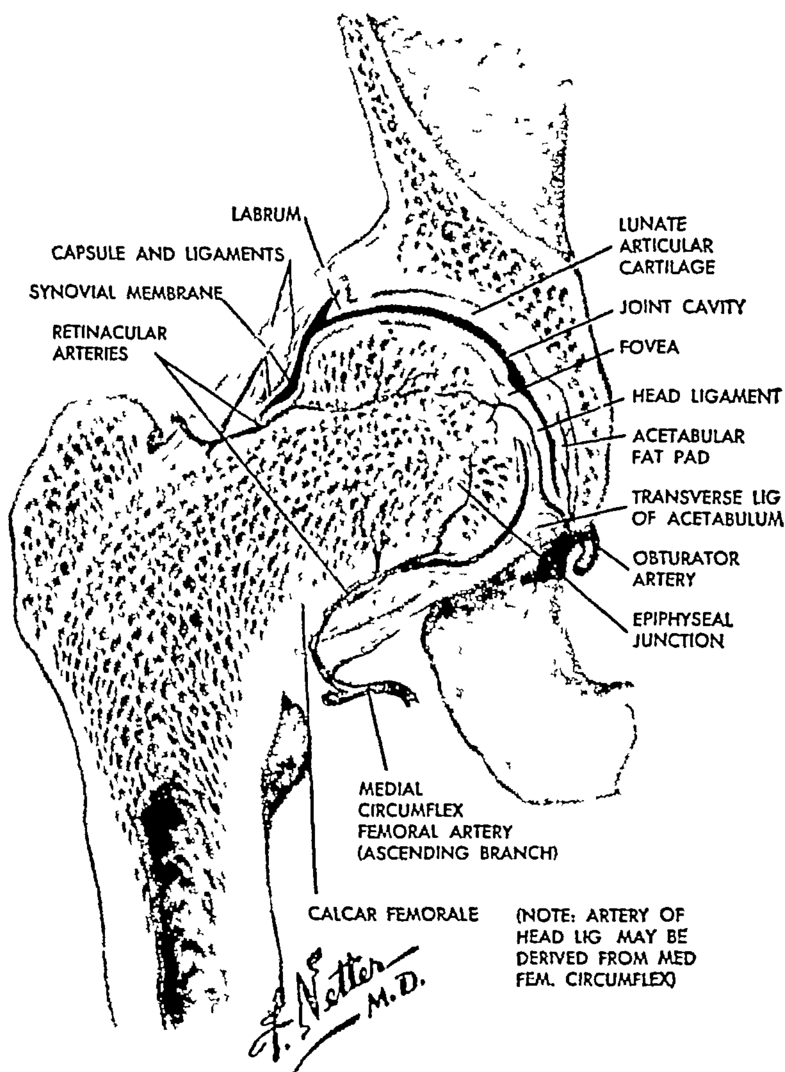
3 The nutrient vessels of the femur send branch to anastomose with the retinacular vessels, as show in the plate

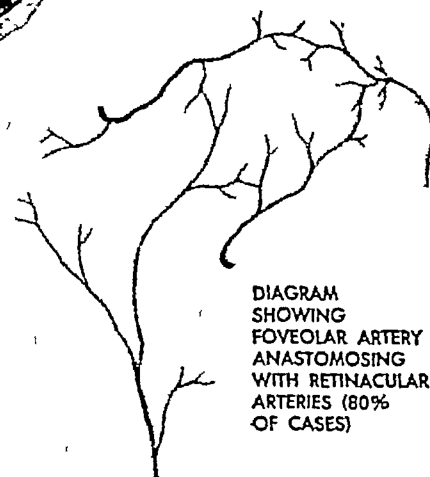
These facts emphasize the necessity for due ca in operative procedures on the hip to preserve the vessels when a viable head is desired

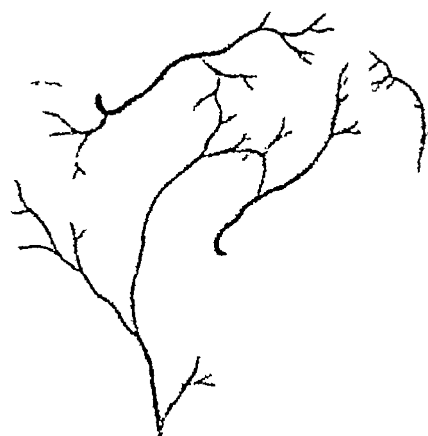
(Moseley, H F Disorders of the hip, Ciba Clin cal Symposia 5 5-30)








DIAGRAM SHOWING FOVEOLAR ARTERY ANASTOMOSING WITH RETINACULAR ARTERIES (80% OF CASES)


FOVEOLAR ARTERY VERY SMALL — REACHING ONLY AS FAR AS THE FOVEA — NOT ANASTOMOSING (20% OF CASES)

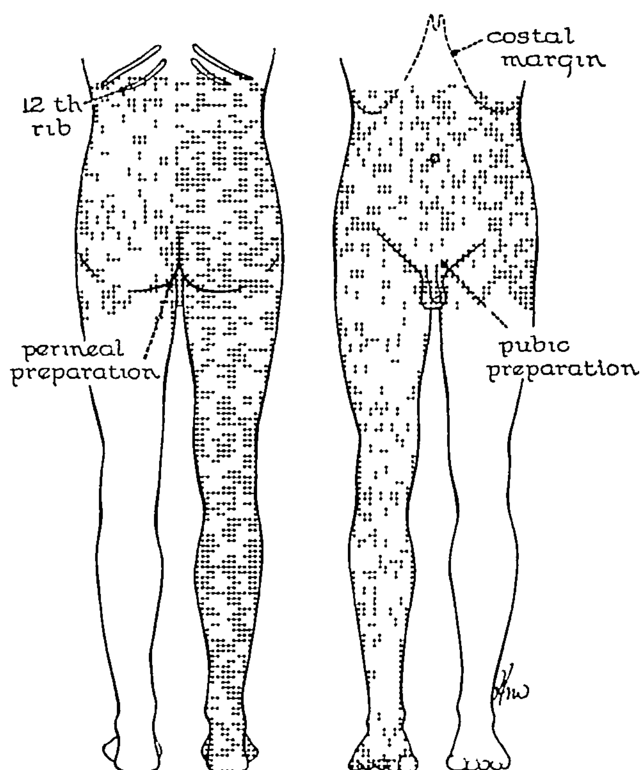


FIG 43 Area of skin preparation for operative procedures on the hip

The area of skin preparation for operative procedures on the hip best includes the trunk below the costal margins anteriorly and above the twelfth ribs posteriorly, the groin and the upper thigh on the opposite side, and the whole limb on the side of the operation Careful shaving and cleansing of the pubic and the perineal areas are essential



FIG 44 Posturing and draping for the anterolateral exposure

(A) The patient is postured in the supine position He is turned somewhat to the left side, with the sandbags placed beneath the right buttock A small pillow or a sandbag is under the right knee

(B) The foundation sheet has been placed beneath the extremity for operation and over the opposite limb The foot, the ankle and the leg have been received into a towel, which is covered by stockinet to above the knee The anesthetic area is closed off by a small sheet over the screen extending from the pelvic brim

(C) The draping of the sterile area is completed with the application of the laparotomy sheet through which the limb has been passed A small sterile towel can be applied to cover the exposed skin while the incision is being made Once towels are attached to the edges of the skin incision, the wound will be closed off from all exposed skin

PLATE 52

Anterolateral or Iliofemoral Exposure

This is an exposure developed by Smith-Petersen, it affords an excellent approach to the anterior and the superior aspects of the joint It was employed by its originator for the reduction and the pinning of the subcapital fractures by the open method It is used for orthopedic operations, such as the arthroplastic procedures utilizing the Vitallium cup or acrylic or Vitallium prosthesis for femoral head replacement It is also used for arthrodesis of the joint

The patient is placed in the supine position with a large sandbag under the buttock on the affected side The skin incision passes along the anterior third of the iliac crest, down the thigh between the tensor fasciae latae and the sartorius for six or more inches before curving backward, as shown in a

The incision is deepened along the iliac crest down to bone, and the gluteal mass is separated downward by subperiosteal dissection from the abdominal musculature and sartorius, which are retracted upward as the iliac crest is bared The anterior incision is deepened, exposing the anterior border of the ilium down to the anterior inferior spine and the origin of the rectus femoris As the deeper dissection proceeds, branches of the external femoral circumflex vessels will be sectioned

In c, the rectus femoris tendon has been divided and turned downward, exposing the capsule The capsule may be opened in various ways, but a T incision along the anterosuperior portion of the neck, which leaves a cuff of capsule on the acetabulum, is satisfactory

In d, a subcapital fracture is illustrated It will be seen that if displaced this could be reduced under direct visualization, or the head could be removed and replaced by a prosthesis if required The posterolateral exposure has been found to be even more satisfactory for both these procedures, but the anterolateral exposure is best for arthrodesis and for insertion of the Vitallium cup

(Moseley, H F An Atlas of Surgical Exposures, North Chicago, Abbott)

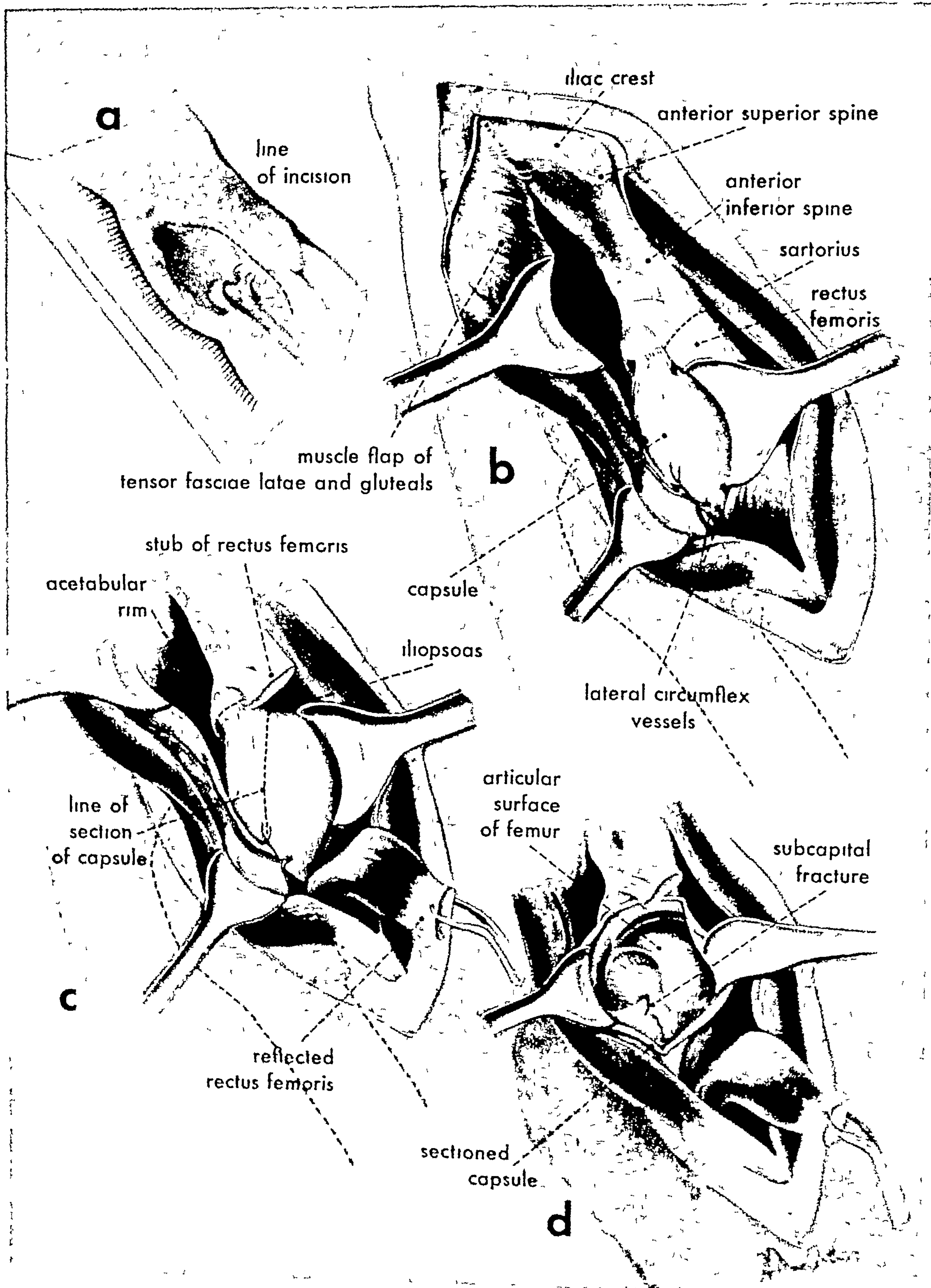

a
line
of incision
iliac crest
anterior superior spine
anterior
inferior spine
sartorius
rectus
femoris
muscle flap of
tensor fasciae latae and gluteals
b
stub of rectus femoris
acetabular
rim
capsule
iliopsoas
lateral circumflex
vessels
line of
section
of capsule
articular
surface
of femur
subcapital
fracture
c
reflected
rectus femoris
sectioned
capsule
d



Fig 45 Posturing and draping for the lateral exposure of the hip

(A) The patient is postured on the orthopedic table for a pinning of a fractured hip The right foot and ankle have been well padded and firmly attached to the footpiece The limb is horizontal and in 20° to 30° internal rotation The left limb is fixed similarly but with the knee flexed to permit the placement of the x-ray tube

(B) The foundation draping is arranged The x-ray apparatus for the anteroposterior view is now in position

(C) The draping of the sterile area is completed with the application of a laparotomy sheet which covers the first x-ray apparatus The second x-ray apparatus for the lateral view of the femoral neck is introduced either between the legs, beneath the drapes or beneath the flexed left knee

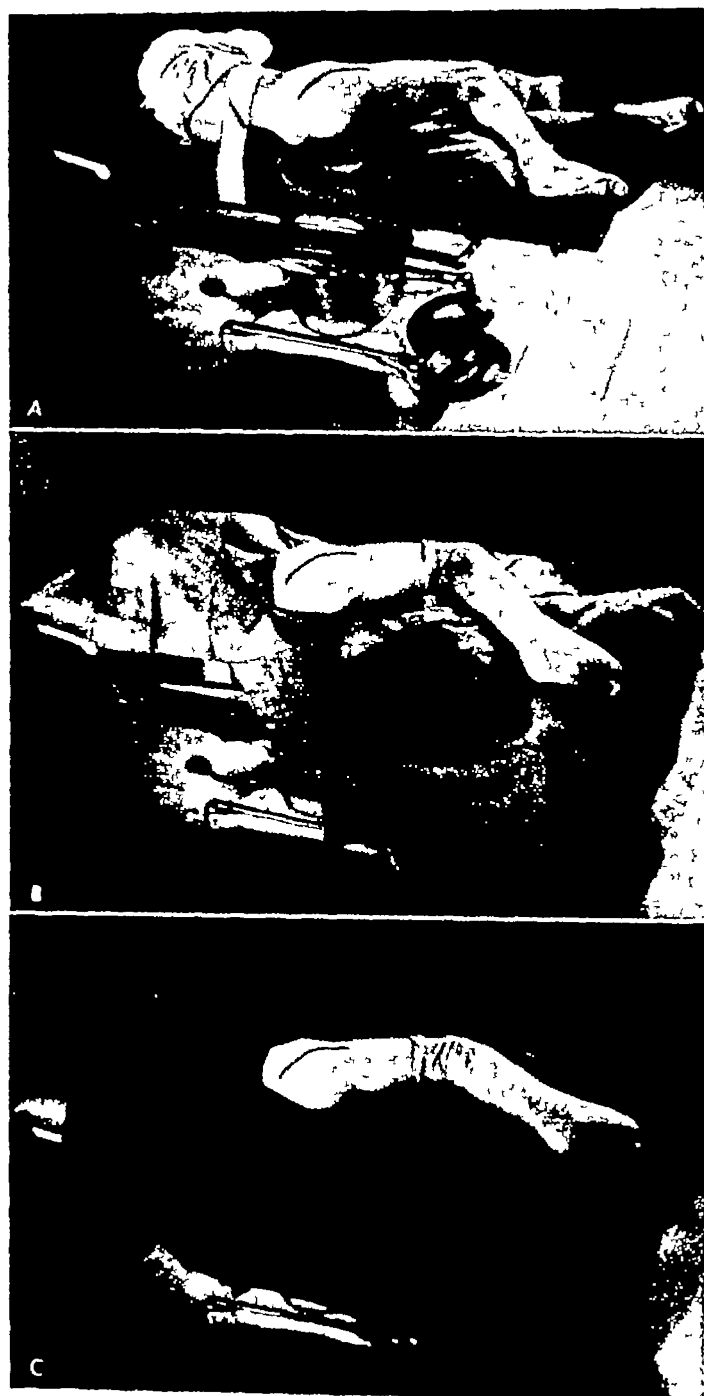


FIG 46 Posturing and draping for the posterolateral exposure of the hip

(A) The patient is postured in the right lateral position He is held in this position by the kidney rest, sandbags along the anterior aspect, a pillow between the knees, and a firm wide band of adhesive tape round the body at the level of the lower ribs

(B) The foundation draping is placed with the limb covered to the lower thigh so as to be sterile for manipulation

(C) The toweling of the sterile field is completed with the application of a laparotomy sheet through which the limb has been passed A small towel may be applied to cover the exposed skin until the incision has been made and towels are attached to the edges of the wound

PLATE 53

Lateral Exposure

The lateral exposure is standard for the insertion of the Smith-Petersen pin with or without the use of a side plate

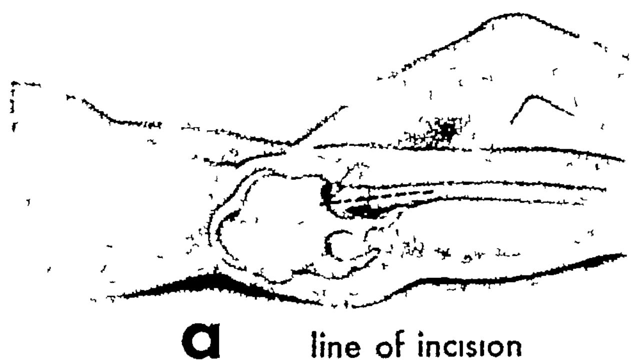
The patient is placed on the Hawley or other orthopedic table in the supine position The fracture is reduced by manipulation and the limb is fixed in slight abduction and internal rotation of 20° to 30°, as seen at the patella The opposite thigh and knee are flexed to permit positioning of the x-ray unit for the lateral views of the hip The operation proceeds after the films have disclosed adequate reduction of the fracture

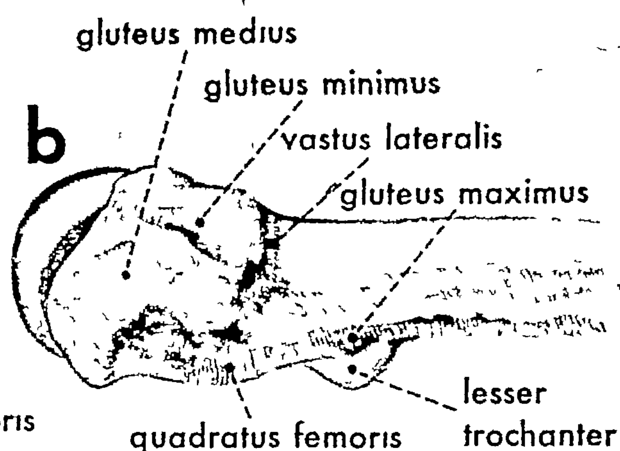
The incision is a longitudinal one, from the tip of the trochanter along the line of the femoral shaft. The muscles to be sectioned are visualized for the surgeon in c and the main origins and insertions of the muscles in b The incision divides the skin, subcutaneous tissue and then the iliotibial tract This exposes the vastus lateralis, which is sectioned to the bone, as shown in d The point for inserting the guide wire and pin is indicated and is on the average 1¼ inches below the tubercle of the vastus lateralis origin If necessary, the neck can be palpated digitally in order to get the general alignment The split in the vastus lateralis can be extended if a side plate is to be applied.

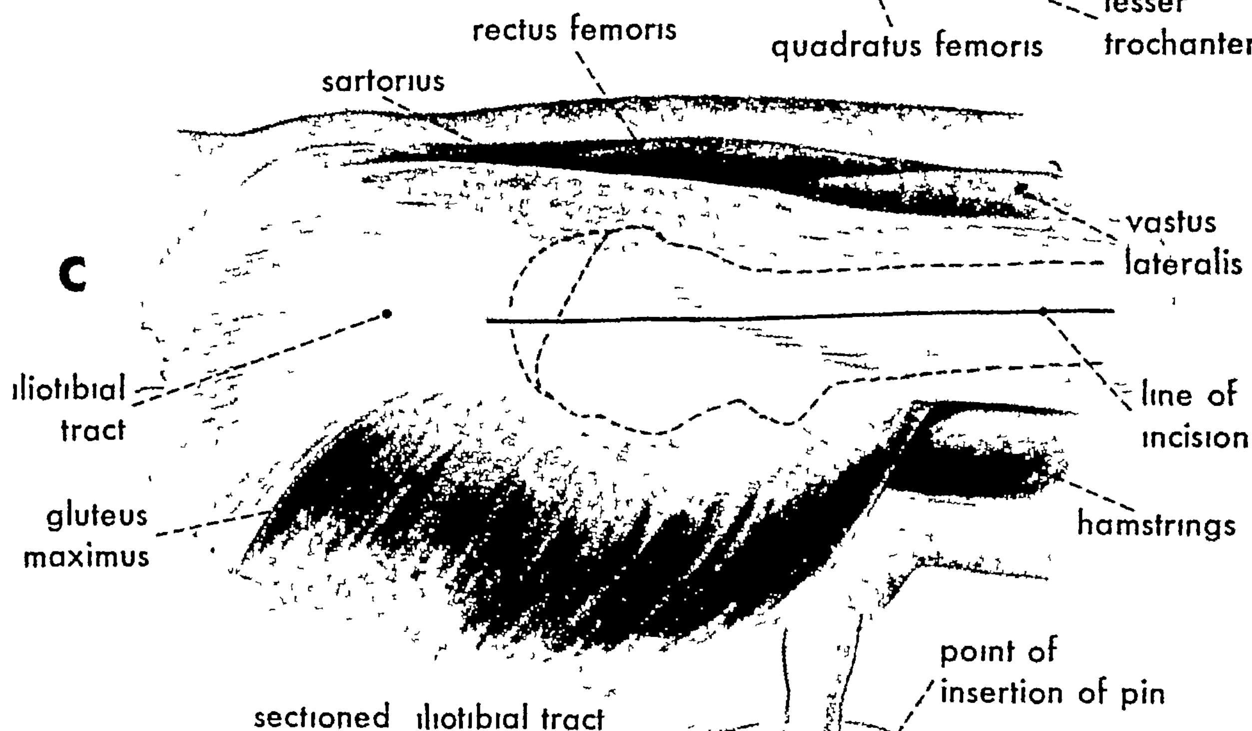
In e, the varying angles formed by the axis of the femoral neck and shaft are shown This angle is greater in the young, and it is greater in males than in females In the adult, it may vary from 110° to 140°, but averages around 120° The line for insertion of the guide wire and pin is also indicated at *a* This line makes a variable angle with the lateral surface of the femur, and is best estimated on the roentgenogram before operation

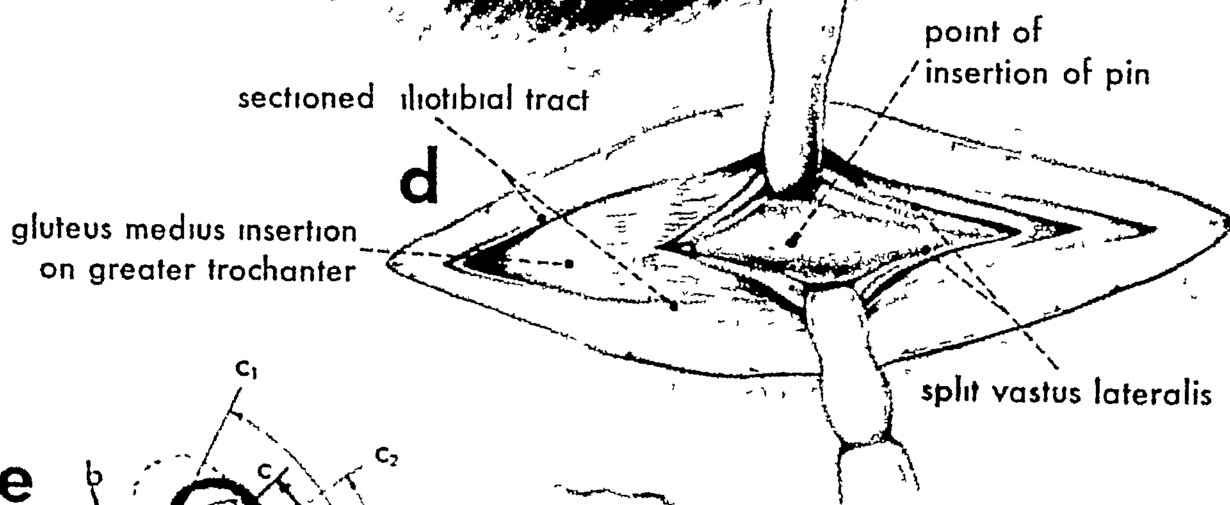
In f, the axis of the femoral neck is viewed in relation to the horizontal plane Normally, an angle of 12° is formed between the axis of the neck and the horizontal axis of the lower femoral condyles This is called the angle of torsion However, from the point of view of operation on fractures of the neck, the positioning of the limb is arranged so as to bring the axis of the neck into the horizontal plane to facilitate the insertion of the pin as seen in the lateral roentgenograms This is achieved by fixing the limb in the stirrup in 20° to 30° internal rotation as judged by the position of the patella

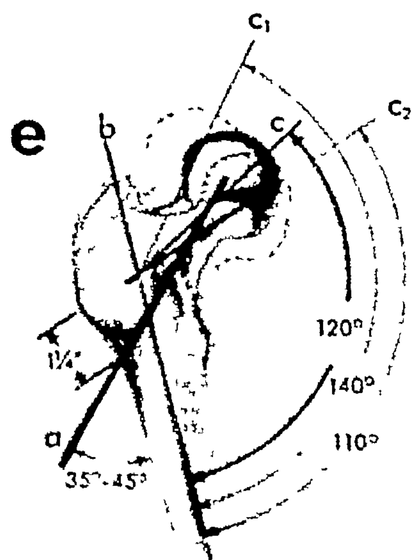
(Moseley, H F An Atlas of Surgical Exposures, North Chicago, Abbott)


a
line of incision


b
gluteus medius
gluteus minimus
vastus lateralis
gluteus maximus
lesser trochanter
quadratus femoris


c
rectus femoris
sartorius
vastus lateralis
iliotibial tract
line of incision
gluteus maximus
hamstrings


d
point of insertion of pin
sectioned iliotibial tract
gluteus medius insertion on greater trochanter
split vastus lateralis


e
c1
c2
b
c
120°
140°
110°
1¼"
a
35°-45°

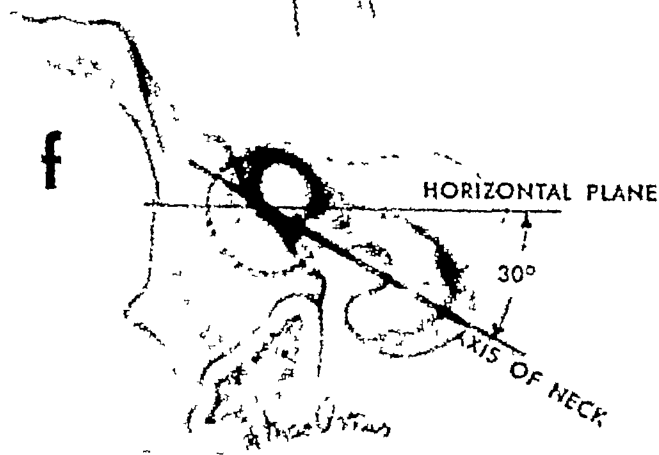

f
HORIZONTAL PLANE
30°
AXIS OF NECK

PLATE 54

Posterolateral Exposure

This exposure has been developed by Gibson from the posterior approach of Langenbeck and has gained rapid popularity for the prosthetic replacement of the femoral head in those presenting subcapital fracture or degenerative arthritis

The patient is placed on his sound side and held there, the kidney supports being used The incision follows a line from a point three inches anterior to the posterior superior spine downward and forward to the anterior border of the trochanter, and then downward along the shaft of the femur In this way it passes just anterior to the muscular fibers of the gluteus maximus and is in avascular aponeurotic tissue throughout It is rarely necessary to carry the upper limb of the incision more than halfway from the trochanter to the iliac crest

As the flaps are separated on each side, the great trochanter with the insertion of gluteus medius is visualized, as in b A curved forceps is passed beneath this tendon, which is then divided from before backward, followed next by the deeper tendon of gluteus minimus Dr Gibson divides the glutei medius and minimus together and from behind forward The rotation of the limb by the assistant facilitates this step The short rotators are shown in c, but they are not usually visualized to this extent at operation

The capsule is opened, as is indicated in d, exposing the superior portion of the neck, which in this case presents a subcapital fracture Dr Gibson prolongs the capsular incision the full extent of the intertrochanteric line, thus peeling off the iliofemoral ligament as a flap It will be seen at once that the fracture could be reduced under direct visualization and a pin inserted through the exposed shaft area, or the head could be removed and replaced by a prosthesis This would appear the easier and the preferable approach for both these procedures

In e, the limb is shown flexed and externally rotated to secure dislocation of the head It will also be observed that, with this exposure and the head dislocated, it is easier to direct the shaft of the prosthesis down the neck of the bone and feel its exit on the cortex of the shaft

This exposure is also valuable for open reduction and fixation of acetabular fractures associated with posterior dislocations of the hip, and may be extended to visualize the sciatic nerve when this structure is injured in such dislocations

(Moseley, H F An Atlas of Surgical Exposures, North Chicago, Abbott)

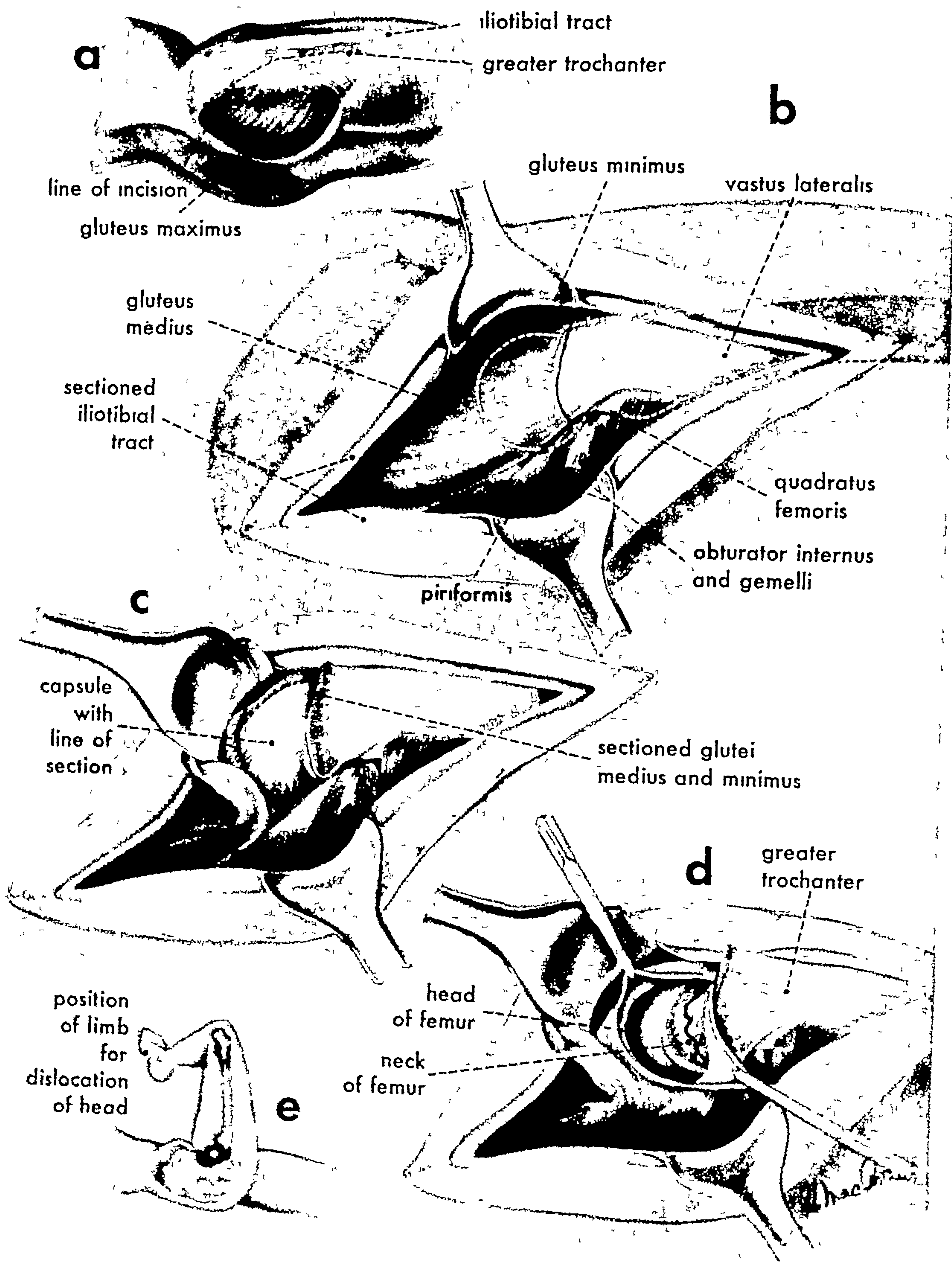

a
iliotibial tract
greater trochanter
line of incision
gluteus maximus
b
gluteus minimus
vastus lateralis
gluteus medius
sectioned iliotibial tract
quadratus femoris
obturator internus and gemelli
piriformis
c
capsule with line of section
sectioned glutei medius and minimus
d
greater trochanter
head of femur
neck of femur
position of limb for dislocation of head
e

PLATE 55

Operative Procedures on the Hip

The drawings on this plate summarize the procedures for which the preceding exposures are most commonly employed These are

1 The Smith-Petersen nail with and without a side plate for fractures of the femoral neck and the trochanteric region

2 Arthrodesis of the hip by the extra-articular and the intra-articular methods usually performed for monarticular disease such as tuberculosis

3 The femoral head prosthesis which has replaced the mold arthroplasty devised by Smith-Petersen The acrylic prosthesis introduced by Judet appears to be losing popularity to those of stainless steel and Vitallium Furthermore, those with an intramedullary shaft, such as the Moore prosthesis, are in more frequent use The report of Lambert *et al* indicates that the posterolateral approach is that in most general use for femoral head replacement

(Moseley, H F Disorders of the hip Ciba Clinical Symposia **5** 5-30)

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Films:

1 Vitallium Cup Arthroplasty (1946) (By M N Smith-Petersen, M D , Boston)

2 reels, 16 mm , silent color

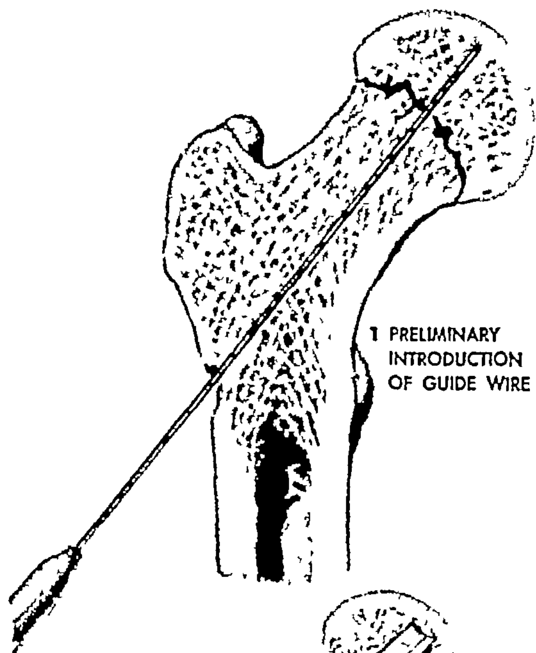
Procurable from Davis & Geck, Inc , 1 Casper St , Danbury, Conn

2 Surgical Approaches to the Hip Joint (by use of animated diagrams and actual dissection, approaches to the hip joint from the anterolateral, lateral and posterolateral aspects are shown) (1951) (By LeRoy C Abbott, M D , Donald B Lucas, M D , Paul A Gregorieff, M D , J Robert Close, M D , and J B de C M Saunders, M B , San Francisco)

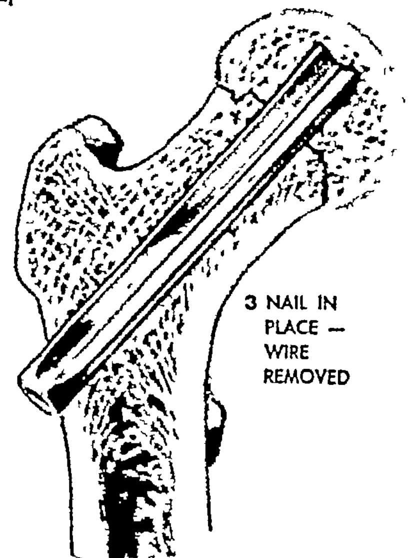
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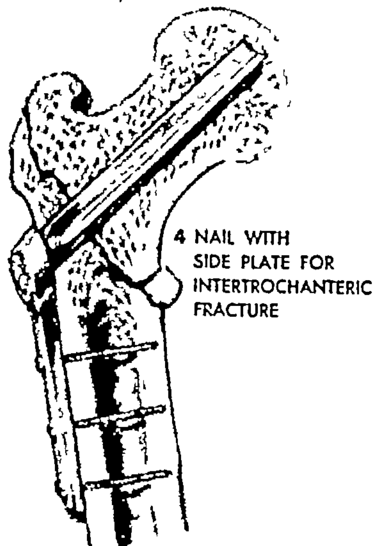
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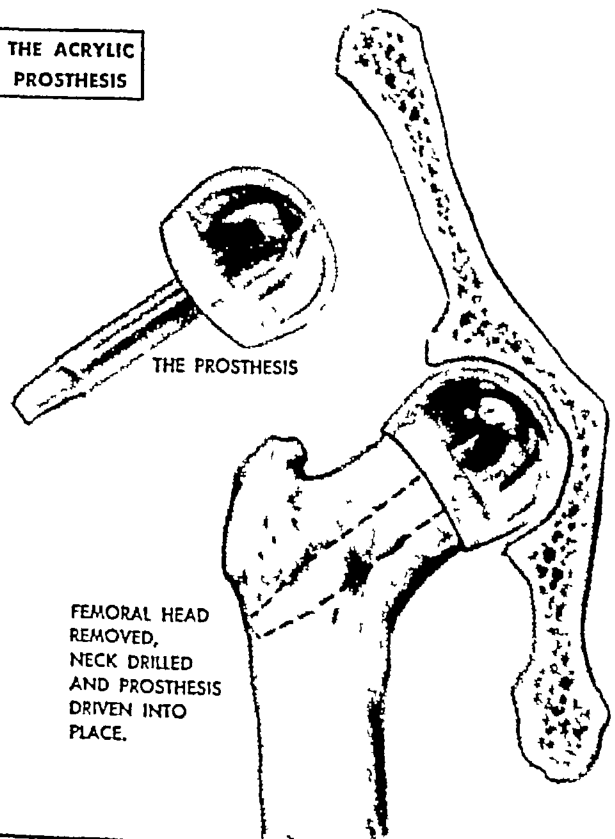
THE SMITH-PETERSEN NAIL

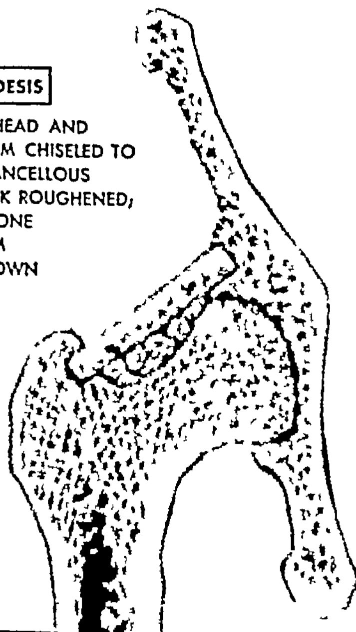












F. Netter M.D.

12

THE THIGH

The *femur* is the longest and the strongest bone in the human body, and it is covered by powerful and massive muscles Its operative exposure on a well-developed male adult is a major procedure, and extensive section of muscle tissue results in considerable hemorrhage For this reason, approaches which follow the fascial planes are indicated when possible

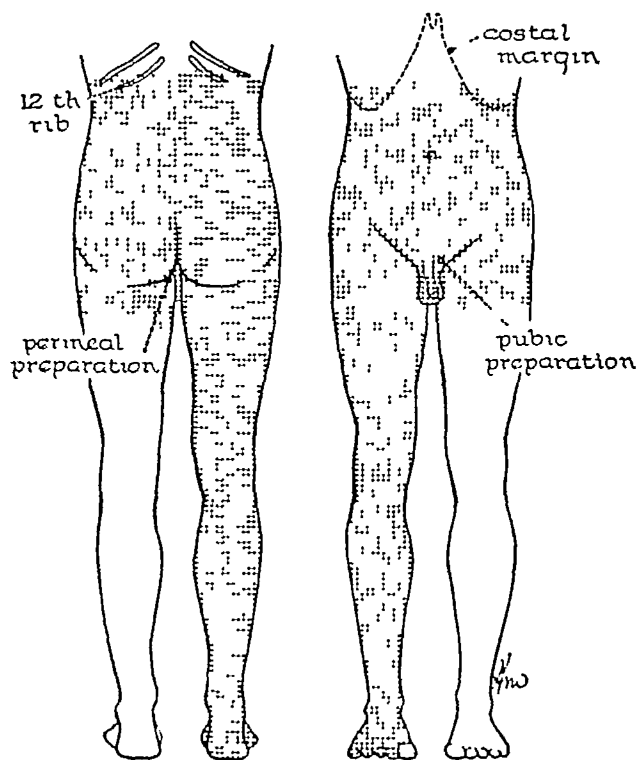


Fig 47 Area of skin preparation for operative procedures on the thigh

The area of skin preparation for operative procedures on the thigh is similar to that for exposures of the hip It includes the whole extremity, the trunk to the ziphoid anteriorly and to L 1 posteriorly, together with careful pubic and perineal preparation

Some surgeons are content to exclude the ankle and the foot and offset this omission by their draping

The important vascular and nervous structures, the femoral vessels and nerve and the sciatic nerve, run in the soft tissues of the anteromedial and the posterior aspects of the thigh This arrangement leaves the anterolateral and the lateral areas free for operative approaches, and in the supine posture these are the most accessible for surgical intervention

In this section, three exposures will be detailed, namely, the anterolateral of Henry and Thompson, the posterolateral, and the posterior described by Bosworth Correlation should be made with Plate 53, which describes the lateral exposure for the upper fourth of the femur, and Plate 63, which illustrates the posterior exposure of the lower end of the femur

Certain facts should be remembered regarding the relative advantages of the various exposures for different areas of the femur

The anterolateral exposure (Plates 56 and 57) is the most generally useful for reduction and internal fixation of fractures of the lower two *thirds of the femoral shaft* There is also ample room for freshening the bone ends and for bone grafting It can be performed with relatively little blood loss It is not, however, so useful for the upper third of the femur, above the nerve and the vessels to vastus lateralis, as the bone is so deeply placed in this area The upper third is probably best approached by the lateral or the posterolateral exposure The lower portion of the femoral shaft can be exposed by continuing distally the anterolateral incision and reflecting the suprapatellar pouch One disadvantage of the



FIG 48 Posturing and draping for the anterolateral exposure of the femur
(A) The patient is postured in the supine position A sterile towel covers the pubic area The anesthetic screen is in place
(B) With the right limb elevated by the orderly holding the foot, the foundation sheet has been laid beneath it and over the opposite extremity The upper limit of the field has been set by a towel clipped round the upper thigh The foot and the ankle are received and wrapped in a sterile towel and covered by stockinet to above the knee
(C) The limb is passed through the opening of the laparotomy sheet, which is used as a coverall

anterolateral exposure is the tendency to quadriceps fixation and subsequent limitation of knee movements

The lateral exposure for the femoral shaft, which is a continuation of the lateral exposure for the trochanteric area in hip pinning (Plate 53), necessitates incision through the bulky vastus lateralis and vastus intermedius muscles It involves division of perforating vessels of considerable size with consequent hemorrhage The wound may be very deep in muscular patients, and, in the opinion of most surgeons the anterolateral exposure is preferable for the lower two thirds of the femur The upper third of the femur, however, is well exposed from the lateral aspect When drainage of infection is required, the lateral approach is considered to be best

The posterior approach (Plate 60) described by Bosworth gives an excellent exposure of the posterior aspect of the femur It follows fascial planes for the most part Provided the perforating vessels are caught before section, hemorrhage may be small in amount In patients of bulky musculature, the wound is of considerable depth, but this may be obviated by the length of the incision. The posterior exposure has two disadvantages The first is that the patient must be placed prone and this position may be difficult from the point of view of the anesthetist and also when it comes time to apply a plaster spica After the internal fixation has been achieved, it will be necessary to turn the patient The second disadvantage is that in the deep wound, the large and important sciatic nerve may be injured This structure must always be located and protected, especially when clamps are being used to reduce the displaced fractures The posterior approach, however, should be available for the properly selected patient, and neoplasms on the posterior aspect will necessitate this avenue It will not be utilized for draining infections because, again of possible secondary complications involving the sciatic nerve

A modification of this posterior approach may

PLATE 56

Anatomy of the Anterolateral Aspect of the Thigh

These illustrations are developed to assist in the understanding of the anterolateral exposure of the femur

In a, the femur is shown from the greater trochanter above to the condyles below The iliopsoas and the adductor muscles with the femoral artery are *in situ* The articularis genu arises from the femur and inserts into the suprapatellar pouch

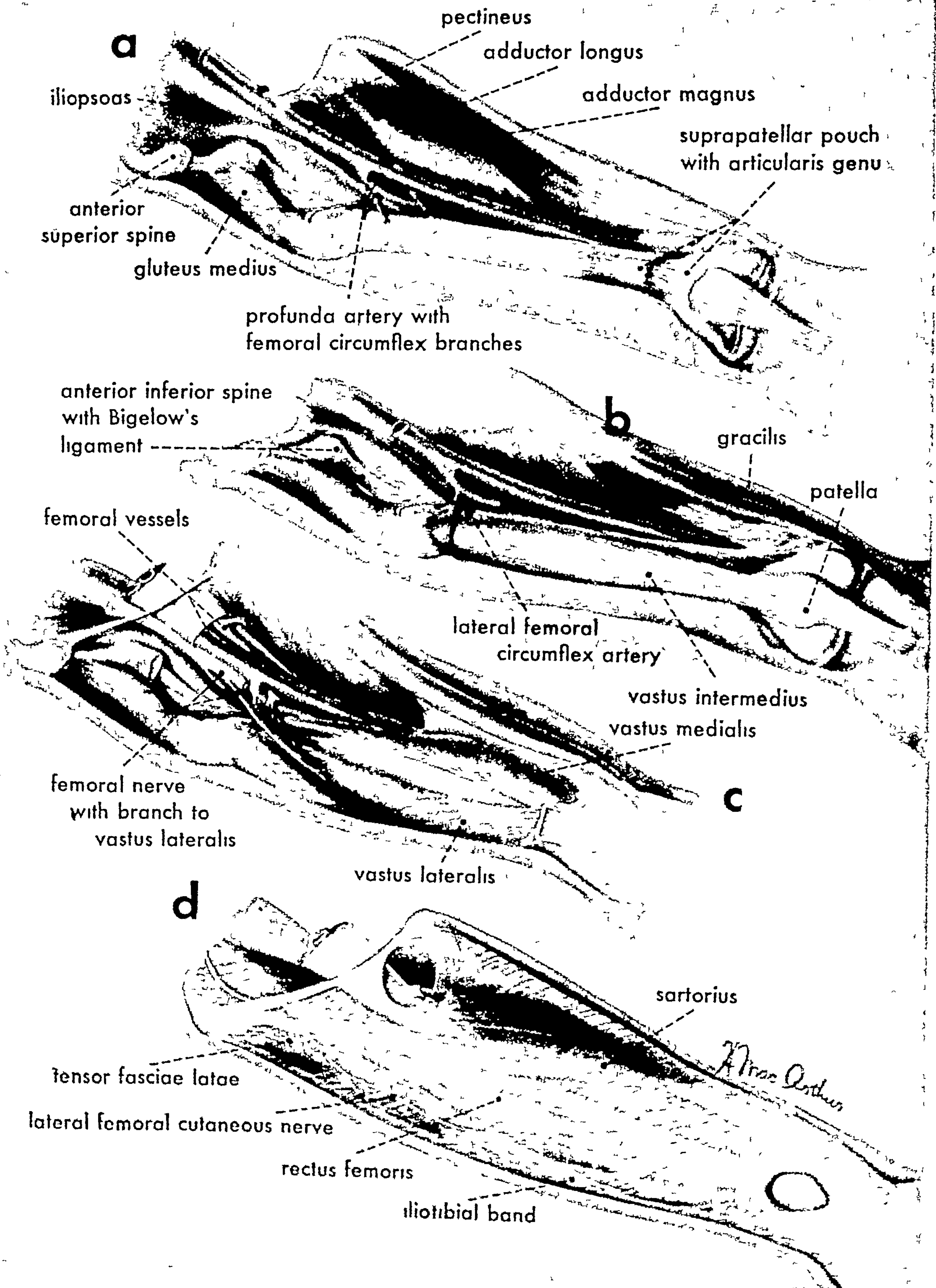
The vastus intermedius is added in b and covers the anterior aspect of the femoral shaft It extends downward to insert into the upper pole of the patella

In c the femoral nerve and the femoral vein complete the neurovascular bundle Two other components of the quadriceps femoris, namely, the vastus lateralis and the vastus medialis, are superimposed on the vastus intermedius These wrap round the lateral and the medial aspects of the femur The important structures to be noted here are the nerve to the vastus lateralis and the vessels accompanying this nerve, which are branches of the lateral femoral circumflex artery and vein This neurovascular bundle courses obliquely downward and penetrates by different branches into the vastus lateralis

Figure d depicts the completion of the musculature with the dense deep fascia overlying this muscle mass The fourth head of the quadriceps, the rectus femoris, is the most superficial component and fuses with the others at the common insertion into the patella The tensor fasciae latae and the iliotibial tract extend from the anterior iliac crest to insert on the tibia This forms the lateral covering of the thigh and is continuous with the deep fascia overlying the quadriceps femoris

It will be seen that a line joining the anterior superior spine and the outer border of the patella courses over the rectus femoris and marks on the surface the line of the anterolateral aspect of the femoral shaft

(Moseley, H F An Atlas of Surgical Exposures, North Chicago, Abbott)



a
pectineus
adductor longus
iliopsoas
adductor magnus
suprapatellar pouch
with articularis genu
anterior
superior spine
gluteus medius
profunda artery with
femoral circumflex branches
anterior inferior spine
with Bigelow's
ligament
b
gracilis
patella
femoral vessels
lateral femoral
circumflex artery
vastus intermedius
vastus medialis
femoral nerve
with branch to
vastus lateralis
c
vastus lateralis
d
sartorius
tensor fasciae latae
lateral femoral cutaneous nerve
rectus femoris
iliotibial band

Plate 57

Anterolateral Exposure of the Femur

This excellent exposure has been developed by Henry and Thompson and is used more commonly than the lateral or the posterolateral approaches The anatomic points will be well understood from Plate 56, which demonstrated the neurovascular supply to the vastus lateralis above and the suprapatellar pouch below This exposure is especially useful for exploring fractures of the femoral shaft between these structures

The patient is placed in the supine position, and the skin incision required is made in the line joining the anterior superior spine and the outer border of the patella

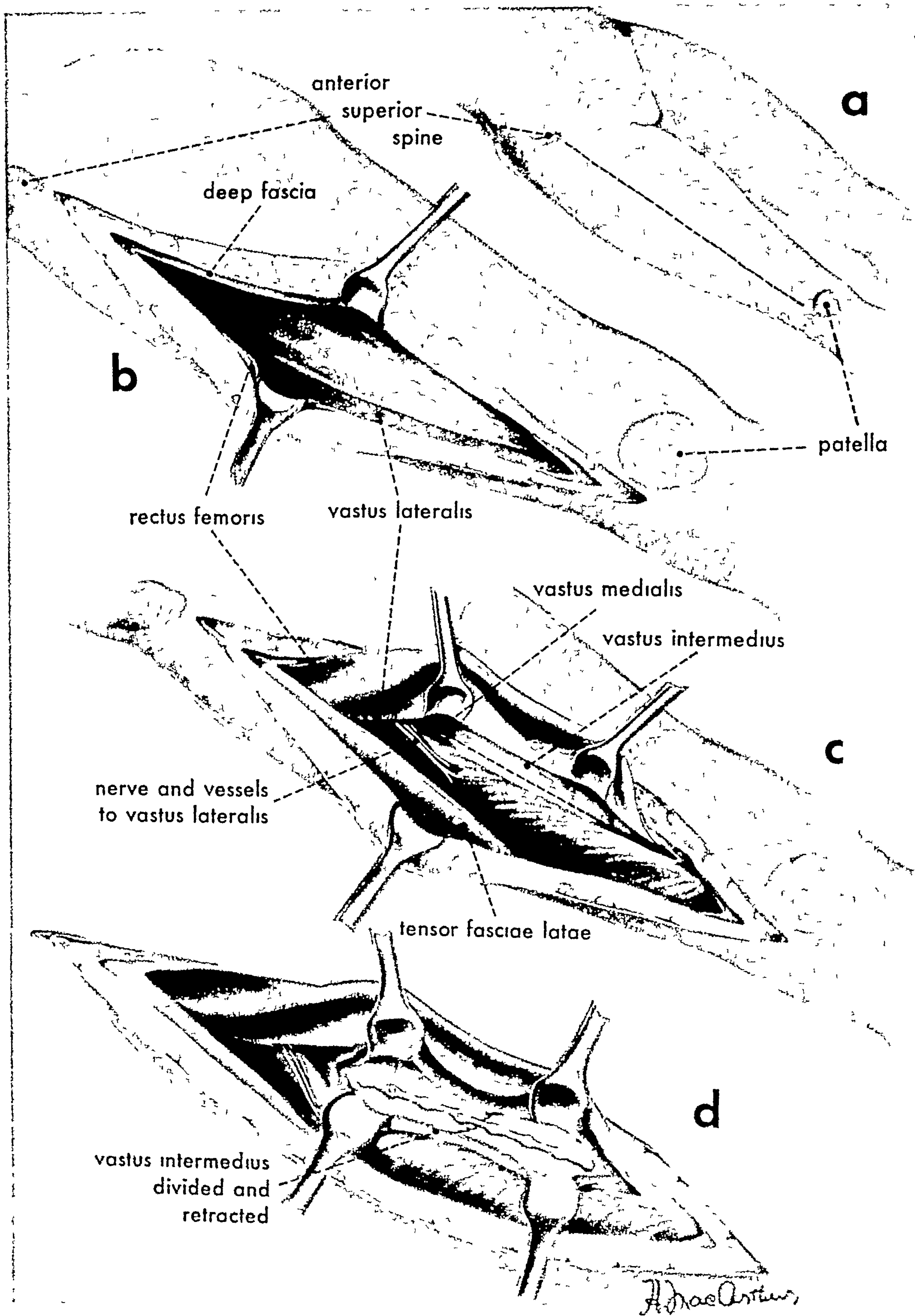
This incision is deepened to section the deep fascia along the lateral border of the rectus femoris The rectus can then be displaced medially, exposing the vastus lateralis and, proximally, the nerves and the vessels passing to this muscle The vastus lateralis is retracted laterally and the vastus intermedius is exposed This muscle is now sectioned in the length of the wound directly to the bone, the anterior and the lateral aspects of the femoral shaft being exposed

Although this approach may be used to expose the upper third of the femoral shaft above the neurovascular bundle to vastus lateralis, the dissection here is deep and most surgeons prefer the posterolateral exposure for this area (Plate 58)

The lower third of the femur can be well visualized by extending the incision distally In this area, the suprapatellar pouch may be opened to remove debris from the joint, or the pouch may be dissected from the femur and maintained intact.

The anterolateral exposure affords an excellent visualization of the lower two thirds of the femoral shaft and is utilized for the open reduction and internal fixation of fractures by plate or intramedullary nail

(Moseley, H F An Atlas of Surgical Exposures, North Chicago, Abbott)



anterior
superior
spine
a
deep fascia
b
patella
rectus femoris
vastus lateralis
vastus medialis
vastus intermedius
c
nerve and vessels
to vastus lateralis
tensor fasciae latae
d
vastus intermedius
divided and
retracted



FIG 49 Posturing and draping for the posterolateral exposure of the femur

(A) The patient is placed in the lateral position with the thigh for operation uppermost A pillow has been placed between the knees

(B) The limb has been elevated and the foundation sheet laid under it, extending as high into the perineal area as possible A second towel has been clipped round the groin as high up as possible The foot has been received into a sterile towel, and the whole leg has subsequently been covered with stockinet

(C) The limb has been passed through the opening of a laparotomy sheet, which is used as a coverall Further local toweling to cover exposed skin can be used as required

be utilized for secondary operations on the femur to avoid going through the area previously scarred by an anterolateral exposure With the patient postured on the affected side, the approach is placed *posterolaterally*, extending distally from the trochanter The incision is through the iliotibial tract and then along the posterior border of the vastus lateralis which is retracted forward The posterior boundary is the lateral intermuscular septum, which passes deeply to insert on the linea aspera The *posterolateral exposure* (Plate 58) is useful for the upper half of the femur, and it has been used more frequently in recent years for the introduction of the Kuntscher nail The anatomic relationships can be understood from a study of the plates.

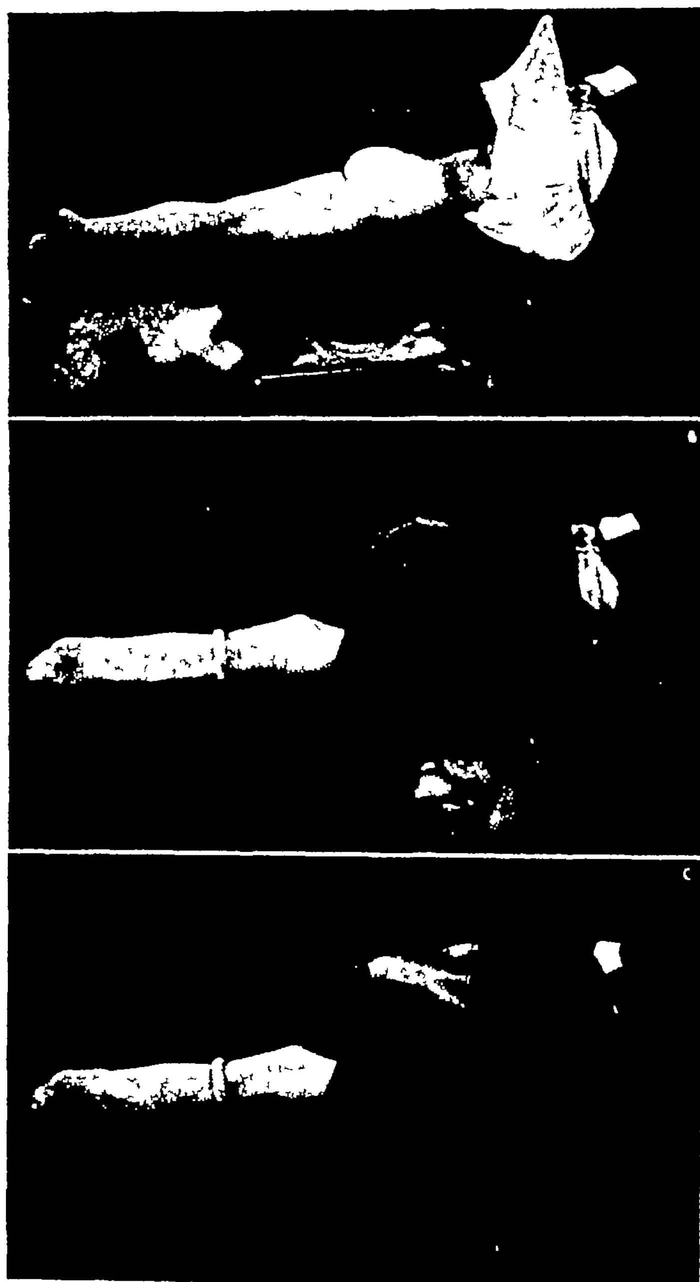


FIG 50 Posturing and draping for the posterior exposure of the femur

(A) The steps are the same as for the anterolateral exposure The patient is postured in the prone position The anesthetic screen is in place

(B) The limb is elevated by the orderly holding the foot, the knee flexing automatically The foundation sheet is applied beneath the limb for operation and over the opposite extremity The upper limit of the field is set by a towel round the thigh arranged as proximally as possible The foot and the ankle are received and wrapped in a towel Stockinet is rolled over this to a point which determines the lower limit of the operative field

(C) The limb is passed through the opening in the laparotomy sheet, which serves as a coverall

PLATE 58

Posterolateral Exposure of the Femur

This avenue of approach has become more widely used with the advent of open reduction and intramedullary fixation for femoral-shaft fractures The upper third of the shaft is deeply placed when approached from the anterolateral aspect (Plate 57), and the posterolateral exposure is, therefore, preferable This latter approach is also superior to the lateral exposure for femoral-shaft fractures as it avoids section of the vastus lateralis where bulky and vascular In the posterolateral approach, hemostasis is obtained by localizing and clamping the perforating arteries near the linea aspera Furthermore, there appears to be less tendency for quadriceps fixation and consequent knee stiffness with the posterolateral as compared with the anterolateral or direct lateral exposures In addition, the laterally postured patient enables flexion and adduction of the thigh during operation and affords the surgeon greater facility when driving the intramedullary nail in the trochanteric area

The drawings on this plate illustrate the anatomy of the muscles as seen from the lateral aspect of the thigh The entire femur is shown in Figures A, B and C In Figure A, note first the linea aspera, to which the gluteus maximus above and the lateral intermuscular septum are attached The vastus intermedius envelops the front of the femoral shaft, extending toward the linea aspera The origin of vastus lateralis is diagrammatically represented in A and added in B Note also the trochanteric bursa superimposed on the tendinous attachments of the gluteus medius and the vastus lateralis Figure C completes the musculature and the iliotibial tract The gluteus maximus and the tensor fasciae latae are seen inserting into the iliotibial tract and fascia lata Posteriorly the biceps femoris is shown

The incision is made midlaterally through the skin and avascular iliotibial tract (Fig C) Once the surface of the vastus lateralis is exposed, the iliotibial tract and the lateral intermuscular septum are retracted posteriorly to expose the posterior edge of the vastus lateralis near the linea aspera Any perforating vessels are secured Two bone elevators are passed deep to this edge of the muscle, and the whole muscle mass is reflected forward, exposing the lateral and part of the anterior surface of the femoral shaft This exposure can be well understood from cross sections E and F, and is visualized in Figure D, in which a Kuntscher nail is shown in course of introduction for a fracture of the midshaft

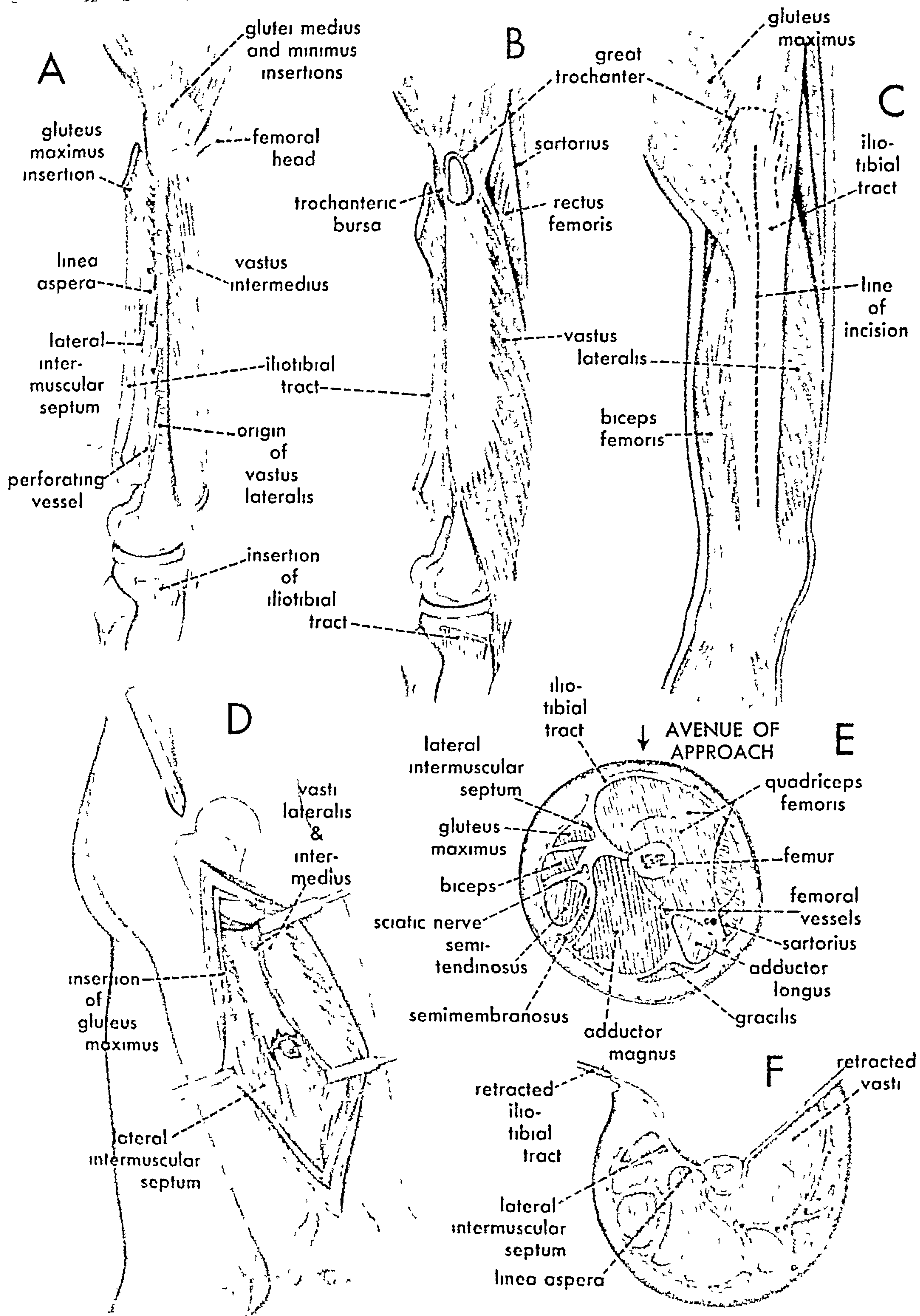

A
glutei medius and minimus insertions
femoral head
gluteus maximus insertion
linea aspera
vastus intermedius
lateral inter-muscular septum
iliotibial tract
origin of vastus lateralis
perforating vessel
insertion of iliotibial tract
B
great trochanter
sartorius
trochanteric bursa
rectus femoris
vastus lateralis
iliotibial tract
C
gluteus maximus
ilio-tibial tract
line of incision
vastus lateralis
biceps femoris
D
vasti lateralis & inter-medius
insertion of gluteus maximus
lateral intermuscular septum
E
ilio-tibial tract
AVENUE OF APPROACH
lateral intermuscular septum
quadriceps femoris
gluteus maximus
femur
biceps
sciatic nerve
femoral vessels
semi-tendinosus
sartorius
adductor longus
semimembranosus
gracilis
adductor magnus
F
retracted ilio-tibial tract
retracted vasti
lateral intermuscular septum
linea aspera

PLATE 60

Posterior Exposures of the Femur

The femoral shaft can be exposed throughout its length by a posterior incision following, for the greater part, the fascial planes between muscles

The approach differs when the exposure required is for the proximal portion of the middle three fifths compared with the distal portion of the middle three fifths of the femur For the proximal portion, the long head of the biceps with the sciatic nerve is retracted medially, whereas for the distal portion these structures must be retracted laterally

Figure A shows the general line of incision in relation to the sciatic nerve, which is the most important structure to be visualized and protected during the operation The line of incision is placed just lateral to the midline of the thigh, and its position and length will depend on the area of femur to be exposed As the wound is deepened, care must be taken to avoid damage to the posterior femoral cutaneous nerve of the thigh (small sciatic nerve), which runs in a groove between the biceps and the semitendinosus muscles deep to the aponeurotic fascia

The deep fascia is incised, and, for the proximal exposure, Figure B, the lateral border of the biceps is defined The long head of the biceps and the sciatic nerve are retracted medially, exposing the origin of the short head of the biceps and insertion of the adductor magnus on the linea aspera These muscles are reflected subperiosteally after longitudinal incision is made down to bone Prior to this step, any major perforating or muscular vessels should be clamped and tied The lower edge of gluteus maximus is shown sectioned in this illustration, but this is usually unnecessary

Figure C illustrates the more distal exposure, and the main difference is the lateral retraction of the long with the short head of the biceps and the sciatic nerve

Both these approaches result in a deep wound, which is obviated by a long incision

These exposures may be employed for internal fixation of fractures and for the resection of neoplasms (Bosworth)

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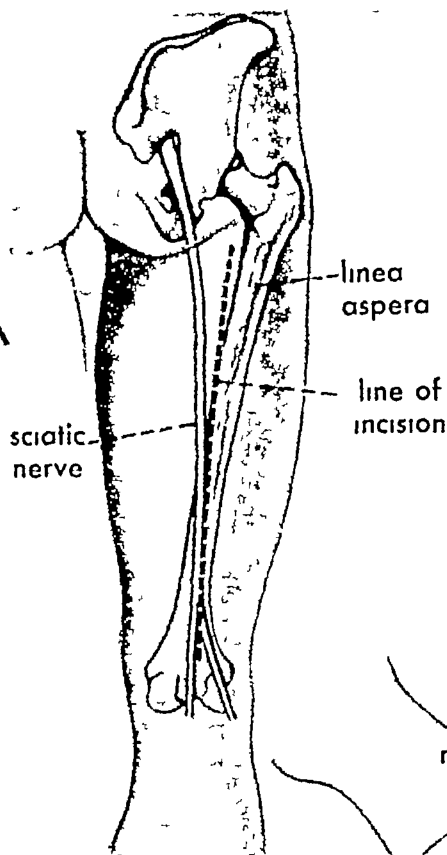
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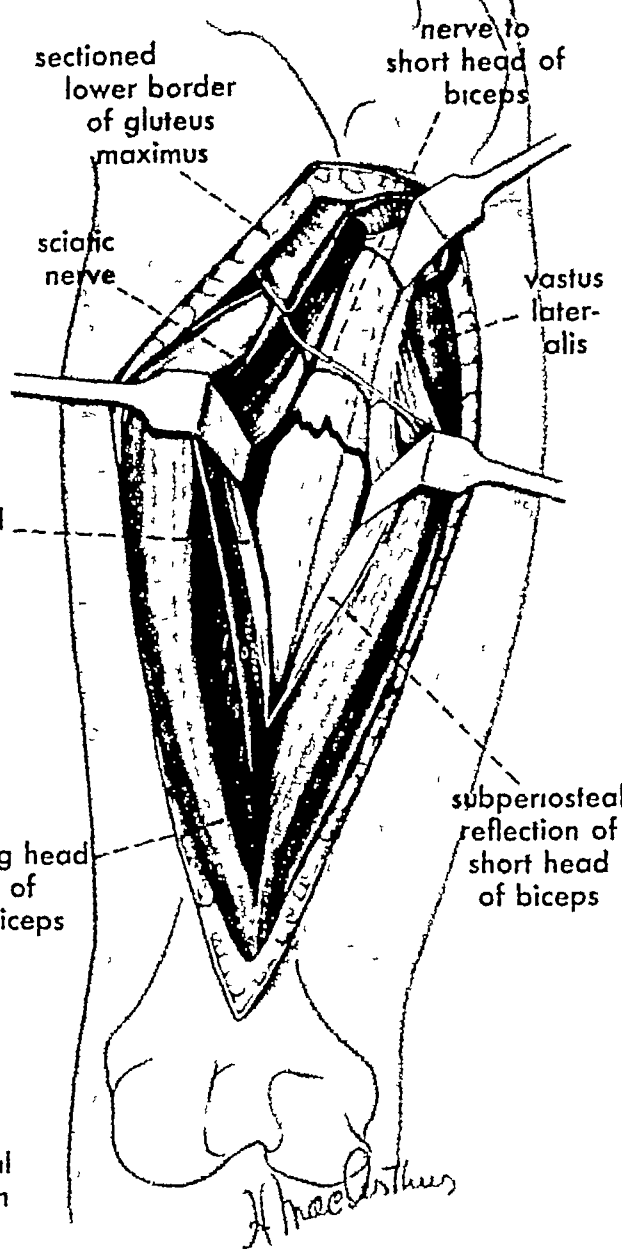
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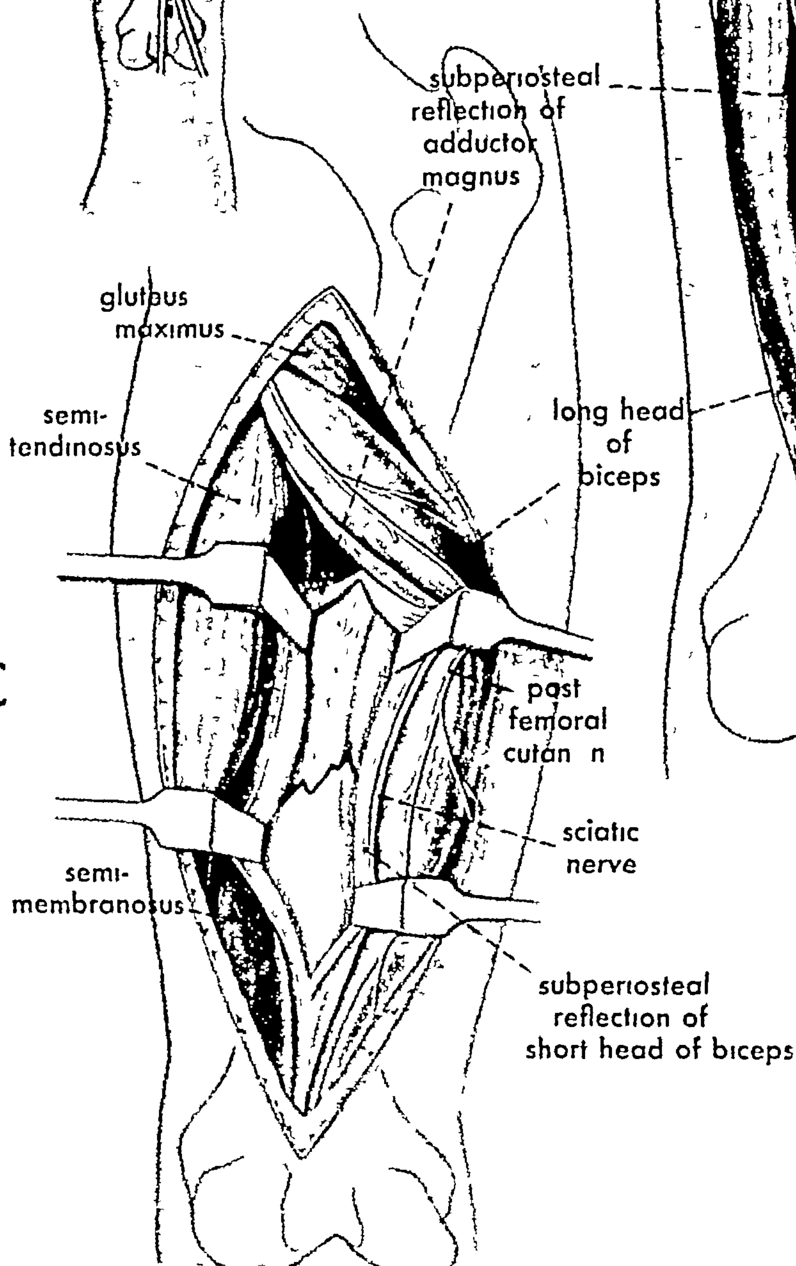
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Film: Supplementary Fixation in Medullary Nailing of the Femur

Producer Veterans Administration, Medical Department, under the direction of Dr Dana M Street, Memphis, Tenn


A
linea aspera
line of incision
sciatic nerve


B
nerve to short head of biceps
sectioned lower border of gluteus maximus
sciatic nerve
vastus lateralis
subperiosteal reflection of adductor magnus
long head of biceps
subperiosteal reflection of short head of biceps


C
gluteus maximus
semitendinosus
post femoral cutan n
sciatic nerve
semimembranosus
subperiosteal reflection of short head of biceps

internal derangements In view of this trend, it cannot be stressed too strongly that this joint, which possesses the most extensive synovial cavity of any articulation, must always be approached with the utmost care in surgical technic

The knee joint is superficially placed on the anterior, the medial and the lateral aspects, which afford the common avenues of approach The patella and the patellar ligament constitute the main anterior barrier Posteriorly, the joint is deeply situated and is covered by the important structures in the popliteal fossa, including the popliteal vessels and the main branches of the sciatic nerve

In this section, the anatomic relations will be depicted with special emphasis on those structures most prone to injury and those structures most significant in the operative exposures

The medial and the lateral parapatellar incisions will be detailed as acceptable for arthrotomy in the respective anterior compartments for meniscus lesions

The medial patellar displacing incision, described by Timbrell Fisher, is the most useful for general exploration of the joint

Incisions for exploration of the anterior and the posterior compartments for complete removal of the menisci or for loose bodies on the medial or the lateral side are also included The use of special meniscus knives permits the standard meniscectomy to be carried out through the anterior compartment alone

The posterior exposure through the popliteal space is also described This is sometimes required for neoplasms and for posterior marginal fractures of the tibia with displacement Excision of a semimembranosus bursa may also necessitate this exposure The wound is deep, and the important vascular and nervous structures must be visualized and protected

The lower end of the femur is probably best exposed through the lower part of the anterolateral exposure of the shaft (Henry) The upper end of the tibia, when involved in bumper fractures displacing the lateral tibial tuberosity, can be explored through a lateral parapatellar incision extended distally along the tibial crest Arthrodesis is performed with wide exposure through a transverse incision sectioning the patellar ligament and capsule, which, with the patella, are reflected upward These latter incisions and exposures are not included in this section Reference to the illustrations will enable the reader to visualize the essential relationships

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FIG 54 *(On facing page)* Incisions in common use for exposures of the knee joint

The medial and the lateral parapatellar incisions are used to gain access to the respective anterior compartments, most frequently for meniscectomy (Plate 61)

The medial patellar displacing incision is the general utility one for wide exposure and exploration of the joint (Plate 61)

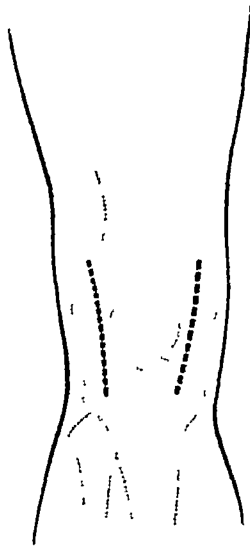
The lateral patellar displacing incision (Kocher) is continuous superiorly with the anterolateral (Henry) exposure of the femur and can be continued distally along the crest of the tibia to expose the upper end of the tibia for fractures of the lateral tibial plateau (Plate 57)

A transverse incision, just below the patella to avoid a scar over a bony surface, can be employed for repair of patellar fractures or for arthrodesis of the joint after section of the patellar tendon (Plate 61)

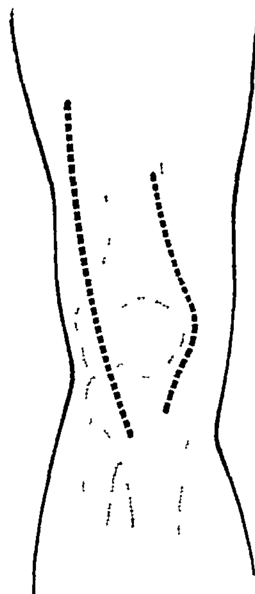
The Jones, the Fisher and the Cave incisions are employed for exploration and excision of the medial meniscus The relation of the incisions to one pattern of the infrapatellar branches of the saphenous nerve is illustrated The parapatellar and the Jones incisions divide this nerve The Fisher and the Cave incisions may just avoid cutaneous nerve section The Cave incision gives access to the anterior and the posterior poles of the meniscus, sparing the medial collateral ligament (Plate 62)

The lateral incision, which deeply sections the iliotibial band in the direction of its fibers, is an alternative to the lateral parapatellar incision for meniscectomy It is especially useful for cysts of this meniscus (Plate 63)

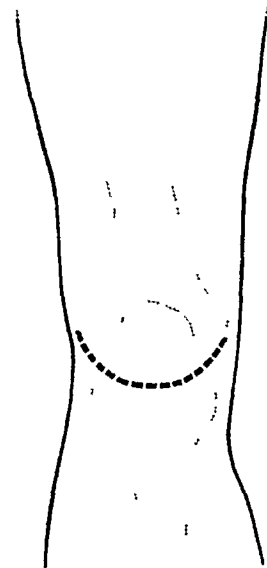
The posterior incision is of the zig-zag type and is the general utility incision for exposure of the posterior aspect of the joint and adjacent soft tissue structures (Plate 63)



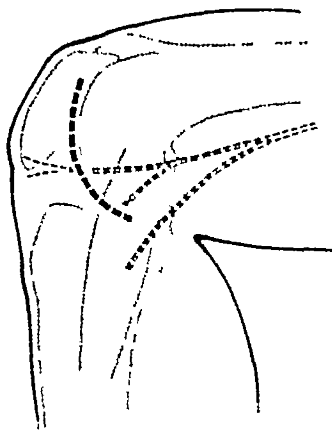
medial & lateral parapatellar incisions



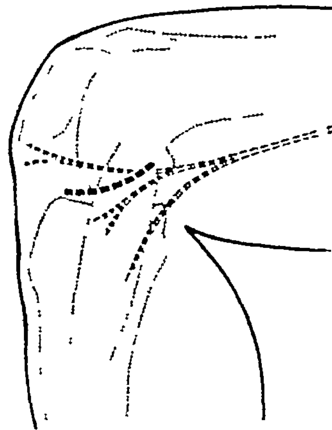
medial & lateral patellar displacing incisions



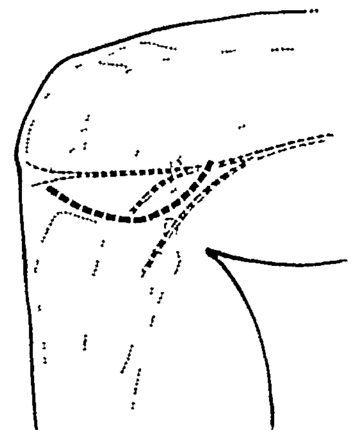
transverse incision



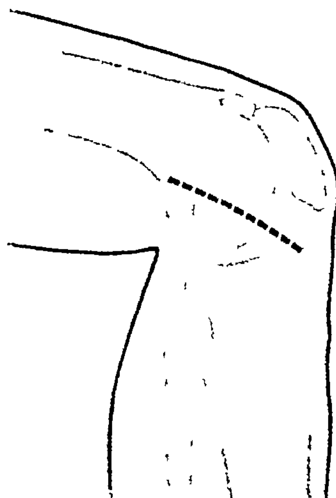
Jones incision



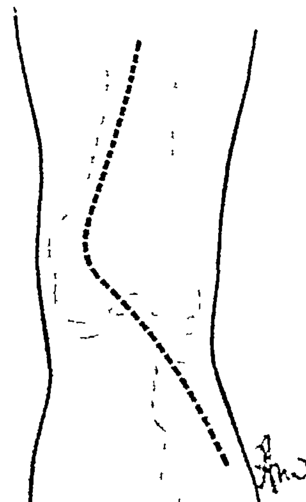
Fisher incision



Cave incision



lateral incision



posterior incision

PLATE 61

Anterior Relations and Exposures of the Knee Joint

The drawings on this plate superimpose the soft tissues on the skeletal framework and illustrate the lateral and the medial parapatellar exposures of the joint.

In a, this bony framework is shown held together by the lateral and the medial collateral ligaments The anterior and the posterior cruciate ligaments occupy the intercondylar space The anterior ligament passes from the anterior surface of the tibia backward and upward to attach on the posterior part of the internal surface of the external femoral condyle, while the posterior cruciate crosses in the reverse direction These important ligaments stabilize the bones in the anteroposterior plane, and operative reconstruction following their rupture is of increasing significance The menisci, between the femoral condyles and the articular surface of the tibia, serve to deepen the sockets of the articulation There is a rich vascular circulation through the geniculate vessels

The synovial membrane, artificially separated from the capsule, is illustrated in b, and also the articularis genu fibers inserting into the suprapatellar pouch The relation of the patella and its ligament to the anterior aspect of the joint is depicted Strengthening the collateral ligaments at their inferior attachment, we find the insertion of the biceps tendon on the lateral side and the insertion of the pes anserinus on the medial side

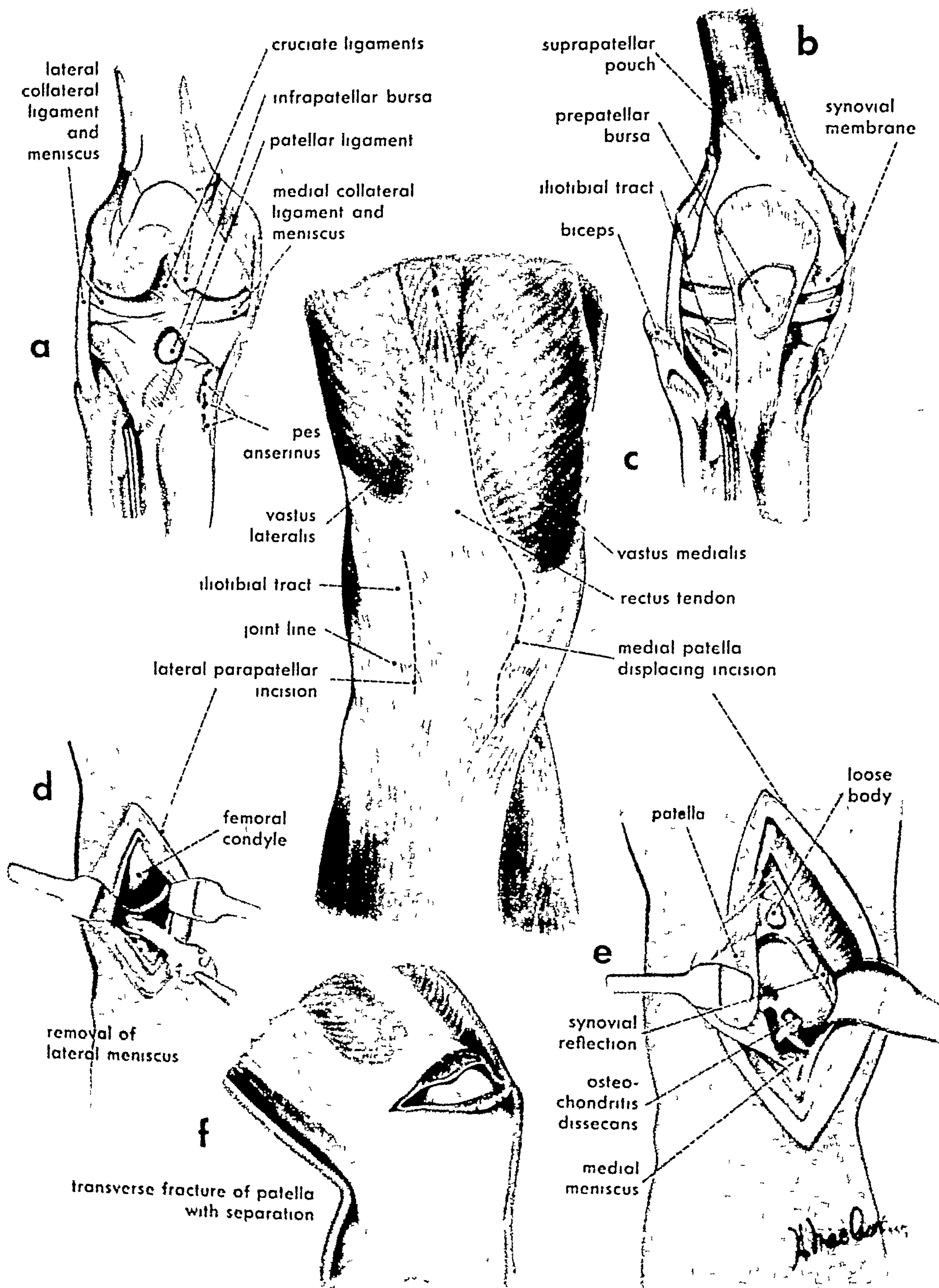
In c, the assembly of the quadriceps femoris is completed This illustration should be correlated with those showing the sequence in Plate 56 The lateral parapatellar incision is most generally utilized for removal of the external meniscus, as in d The incision can be extended proximally into the anterolateral exposure of the femur (Plate 57) in cases presenting a fracture of the lower end of the femur Likewise, it can be extended distally into the anterolateral exposure of the tibia (Plate 64) and will afford access to fractures of the lateral tibial plateau

A similar parapatellar incision is available on the medial side for removal of the medial meniscus. Study of Plate 62 shows that the infrapatellar branch of the saphenous nerve may be sectioned by this incision Anesthesia of the kneeling surface and, later, troublesome paresthesia and painful neuroma formation may complicate the postoperative care

The medial parapatellar incision is extensible proximally between the rectus femoris and the vastus medialis This completes the patella-displacing exposure and gives access to both anterior compartments of the joint as well as the suprapatellar pouch This is represented in e, where an area of osteochondritis dissecans involving the medial femoral condyle, together with the detached fragment in the suprapatellar pouch, is illustrated

In Figure f, a transverse fracture of the patella is present Separation of the fragments occurred because the lateral expansion of the quadriceps tendon on each side was torn Exposure may be obtained by transverse or longitudinal incisions, these are arranged to avoid a scar crossing the patellar surface which would be tender on kneeling

(Moseley, H F. An Atlas of Surgical Exposures, North Chicago, Abbott)



lateral collateral ligament and meniscus
cruciate ligaments
infrapatellar bursa
patellar ligament
medial collateral ligament and meniscus
pes anserinus
a
suprapatellar pouch
b
prepatellar bursa
synovial membrane
iliotibial tract
biceps
c
vastus lateralis
vastus medialis
iliotibial tract
rectus tendon
joint line
medial patella displacing incision
lateral parapatellar incision
d
femoral condyle
removal of lateral meniscus
loose body
patella
e
synovial reflection
osteo-chondritis dissecans
medial meniscus
f
transverse fracture of patella with separation

PLATE 62

The Medial Relations and Exposure of the Knee Joint

The medial meniscus and the medial collateral ligament are the soft tissues of the knee joint most frequently deranged by trauma This plate emphasizes the important anatomic and surgical points related to these structures

Figure a, a cross section, shows the general relations of the menisci and the cruciate attachments on the articular surface of the tibia It will be noted that the radius of curvature of the medial is greater than that of the lateral meniscus

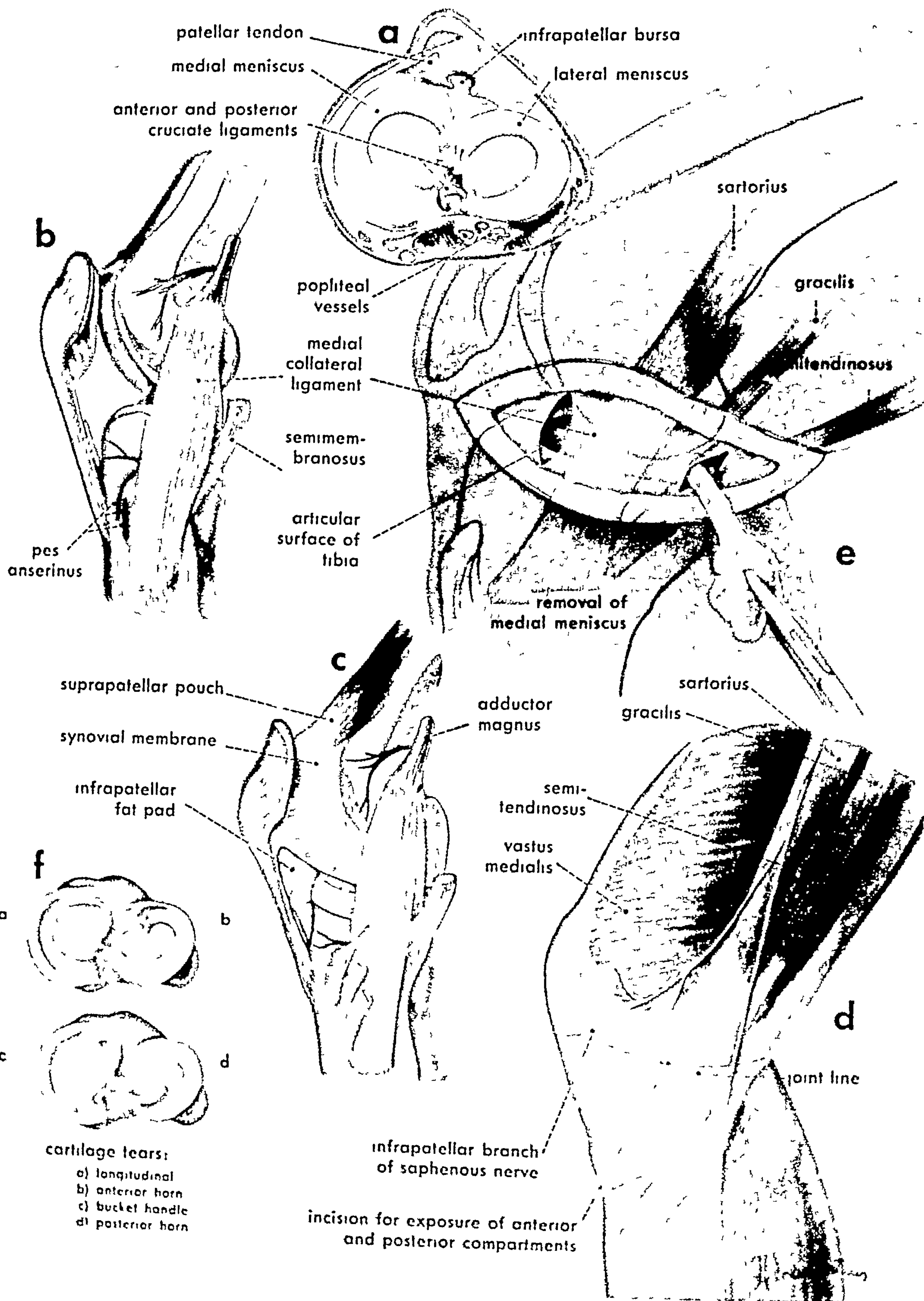
In b and c, the medial collateral ligament arises from the femoral epicondyle and spreads out to insert on a broad area of the tibia A deep portion extends backward to insert at a higher level on this bone The pes anserinus, composed of the tendons of sartorius, gracilis and semitendinosus, crosses over and strengthens the lower insertion of the ligament The joint line and outline of the synovial membrane can be noted in c

Figure d illustrates the completion of the covering musculature The ramification of the saphenous nerve in relation to possible incisions is depicted The dotted line represents the incision through skin and subcutaneous tissue required when the anterior and the posterior compartments must be explored at one operation Once the skin flaps are undercut, the anterior compartment is exposed, as shown in e, by a parapatellar incision through which the anterior horn of the meniscus can be detached The posterior compartment is entered by an incision just anterior to the semitendinosus tendon The anterior freed portion of the meniscus can then be passed out through the posterior incision and the remaining posterior horn of the cartilage dissected and removed Such an exposure is valuable for secondary operations after incomplete removal of this meniscus Exploration of the posterior compartment on the medial aspect of the joint may be indicated for a loose body in this position

Figure f pictures some of the common types of tear suffered by the menisci Tears of the medial are seven to ten times commoner than those of the lateral cartilage

Examination of the drawings b, c, d and e will indicate the relations and the possible lines of incision for carrying out the exposure and the primary repair of the ruptured medial collateral ligament and capsule

(Moseley, H F An Atlas of Surgical Exposures, North Chicago, Abbott)



a
patellar tendon
infrapatellar bursa
medial meniscus
lateral meniscus
anterior and posterior
cruciate ligaments
b
sartorius
popliteal
vessels
gracilis
medial
collateral
ligament
semimem-
branosus
articular
surface of
tibia
pes
anserinus
e
removal of
medial meniscus
c
sartorius
suprapatellar pouch
adductor
magnus
gracilis
synovial membrane
infrapatellar
fat pad
semi-
tendinosus
vastus
medialis
f
a
b
c
d
d
joint line
infrapatellar branch
of saphenous nerve
cartilage tears:
a) longitudinal
b) anterior horn
c) bucket handle
d) posterior horn
incision for exposure of anterior
and posterior compartments

PLATE 63

The Lateral and the Posterior Relations and Exposures of the Knee Joint

Lateral and posterior exposures of the knee joint are not often required The lower end of the femur, joint capsule and upper tibia are deeply placed and difficult to expose adequately on their posterior aspects Besides, the popliteal space transmits the major vessels and nerves to the leg and makes careful dissection essential

It is the preference of most surgeons to approach the fractures from the front or the side This plate, therefore, serves to complete our pictorial understanding of the important structures on the remaining aspects of the joint

Figure a shows the relations of the lateral meniscus to the lateral collateral ligament and tendon of the popliteus The insertions of the biceps and the iliotibial tract are represented in a

The musculature and the iliotibial tract are completed in b The line of incision to enter the anterior and the posterior compartments is illustrated When the capsule is opened anterior and posterior to the collateral ligament, the lateral meniscus can be exposed and removed completely This is the exposure required for total removal of the meniscus under direct vision, but the use of special cartilage knives (Smillie, Downing) obviates the need of opening the posterior compartment in most cases

In Figures d, e and f, the soft tissues on the popliteal aspect are added to the skeletal framework In d, attention should be devoted to the insertion of the semimembranosus on the medial side and to the course of the popliteus tendon on the lateral side

The popliteal vessels enter the popliteal space through the opening in the adductor magnus and pass over the posterior capsule and popliteus as shown in e The sciatic, the common peroneal and the posterior tibial nerves are illustrated

In f, the complete musculature and the lozenge-shaped space between these muscles are shown An S-shaped incision is employed in this exposure in order to prevent keloid formation The incision is deepened on the lateral side of the popliteal vessels and between the posterior tibial and the common peroneal nerves By careful dissection and retraction of the soft tissues medially and laterally, exposure of the lower portion of the femur and posterior capsule of the knee joint is secured

(Moseley, H F An Atlas of Surgical Exposures, North Chicago, Abbott)

a

cut edge
of synovial
membrane

lateral
collateral
ligament

popliteus

lateral
meniscus

iliotibial tract

biceps
tendon

iliotibial tract

vastus lateralis

b

biceps

exposure
of anterior
and posterior
compartments

femoral condyle

c

lateral collateral ligament

removal of lateral meniscus

d

medial
collateral
ligament
and
meniscus

gastrocnemii

semimembranosus

popliteus

soleus

e

popliteal vessels

posterior
capsule

post.
tibial
nerve

common
peroneal
nerve

f

semimembranosus

iliotibial tract

posterior
surface
of femur

biceps

line of
incision

gastrocnemii

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1 Surgical Approaches to the Knee Joint (1951) (By LeRoy C Abbott, M D , Paul A Gregorieff, M D , Donald B Lucas, M D , and J B de C M Saunders, M B , San Francisco)

3¼ reels, 16 mm , sound color

Procurable from Central Office Film Library, Veterans Administration, Vermont Ave and H St , N W , Washington 25, D C

2 Tears of the Medial Meniscus (1947) (By H M Coleman, M D , Toronto)

756 feet, 21 min , 16 mm , silent color *

3 Torn Menisci—Complete or Partial Removal (1948) (By H M Coleman, M D , Toronto)

143 feet, 4 min , 16 mm , silent color *

4 The Regeneration of a Meniscus (1948) (By H M Coleman, M D , Toronto)

158 feet, 4½ min , 16 mm , silent color *

5 The Early Repair of Ruptured Knee Ligaments (1948) (By H M Coleman, M D , Toronto)

575 feet, 16 min , 16 mm , silent color *

* Procurable from Department Medical Illustration, Sunnybrook Hospital, Toronto, Ontario

14
THE LEG

The component bones of the leg, the *tibia* and the *fibula*, are superficially placed from certain aspects and are readily accessible for operative procedures The originators of bone plating, Lane and Lambotte, recognized this fact, as well as the suitability of tibial fractures in the adult for such treatment

Fractures of the tibia and the fibula predominate among the emergencies admitted to our hospitals as a result of the increasing traffic accidents of the automobile era Due to the subcutaneous position of the tibia, a considerable number present open fractures which necessitate primary operative treatment With the early emergency care available to patients, an increasing number of open fractures are receiving reduction and internal fixation at the time of wound excision The number is determined by the time interval between the accident and definitive treatment With chemotherapy the safe period is being extended, and, depending on the extent of soft-tissue loss and the degree of contamination, the interval of 6 to 12 hours may be acceptable in civil practice

Fractures of the tibia, both open and closed, are prone to complications The vascular supply in the lower third is precarious, and delayed union, nonunion and malunion are seen frequently Low-grade osteomyelitis as a result ‹ the initial injury or of the operative treatme may necessitate exposure and saucerization ondary procedures, such as freshening bone en and sliding and onlay bone grafts, are commo ı required for the tibia

The anteromedial aspect of the tibia is eası exposed for the sliding bone graft, and only t saphenous nerve and vein must be considered the approach

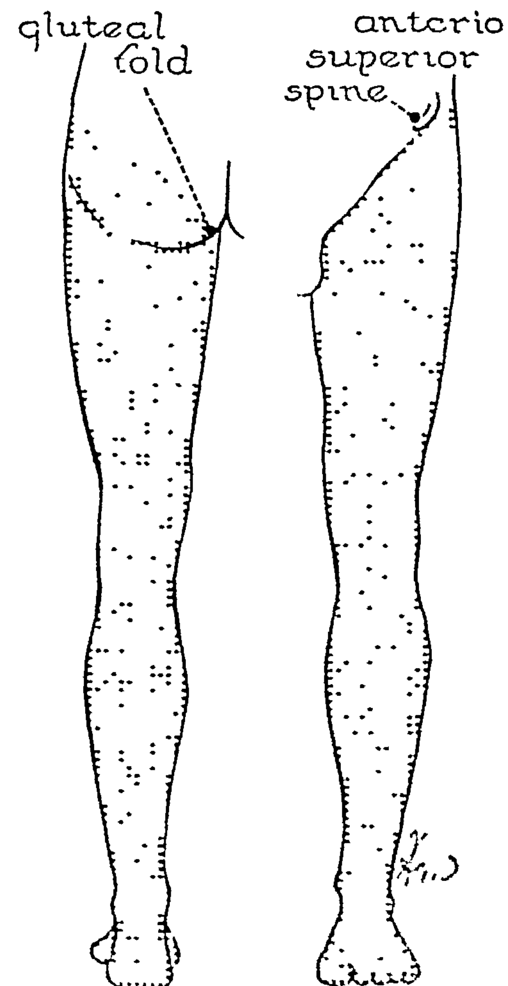


FIG 55 Area of skin preparation for operative procedures on the leg

The area of skin preparation for operative procedures on the leg is the same as for the knee, but greater care must be taken in the cleansing of the ankle and the foot, especially when the field is in the lower half of the leg

The whole limb is prepared from the groin and the gluteal fold superiorly to the toes

For the upper third of the leg, it may be safe to exclude preparation of the foot, which omission is offset by the system of draping

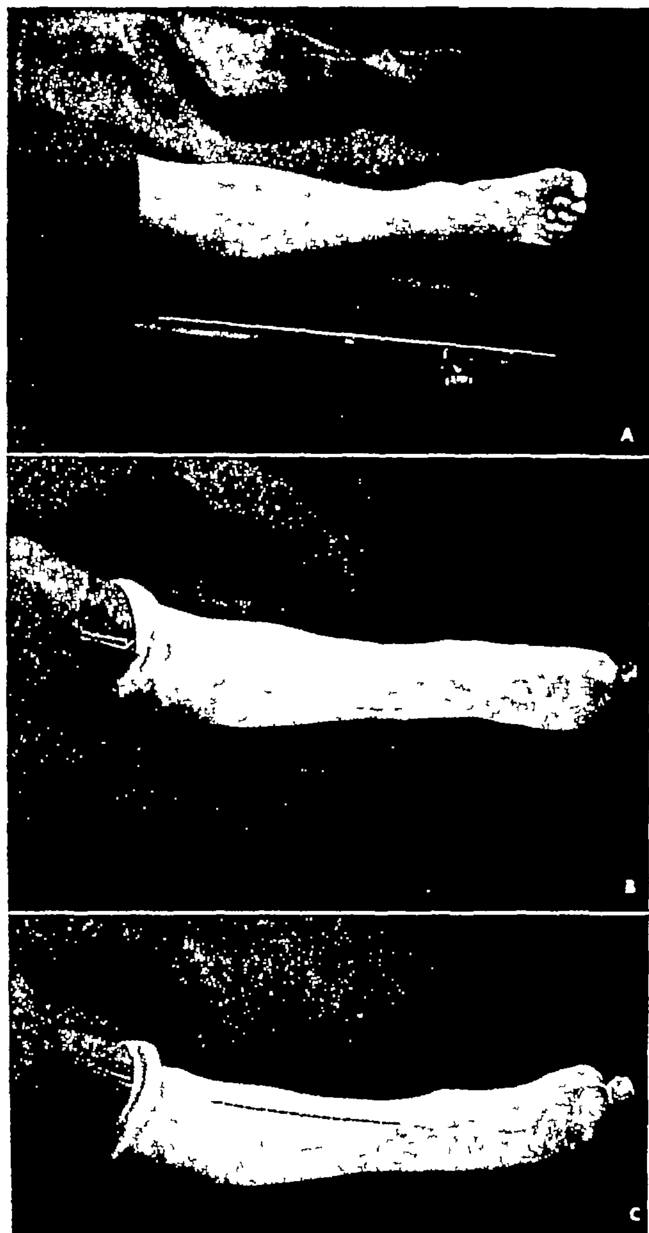


FIG 56 Posturing and draping for operative procedures on the anterior aspect of the leg

If a bloodless field is required, the Esmarch bandage and the pneumatic tourniquet are first arranged

(A) The patient is postured in the supine position

(B) The limb has been elevated by the orderly while the foundation sheet was placed beneath it and over the opposite limb The upper limit of the field is arranged by a towel clipped round at knee level The foot and the ankle have been received into a towel, secured by clips or bandage The foot, the ankle and the leg have then been covered by stockinet

(C) The limb has been passed through the opening in the laparotomy sheet The opening is closed by clip at the level of the knee A line of incision is indicated

Phemister and Gallie advocated the use of the onlay graft, leaving the area of the healing fracture intact in cases in which delayed union or nonunion of a fibrous type occurred This onlay graft can be applied to the anterolateral or the posterior surface of the tibia The anterolateral approach is detailed in Plate 64 It should be remembered that the muscles fill the anterior tibial compartment snugly, leaving little space available for massive onlay grafts or metallic plates on the anterolateral surface of the tibia Care must always be taken that the tension of suture of the soft tissues on closure is not excessive

The exposure of the posterior surface of the tibia for onlay grafting is not covered in this section Some assistance can be gained by correlating with Plate 66 The posterior surface is exposed by upward extension of the posterolateral approach to the ankle Some surgeons tenotomize the tendo achillis to facilitate the exposure Abundant room for massive bone grafting is available, but manipulation and clamping of displaced fractures are performed more readily from the anterior aspect

Operations on the tibia and the fibula are also required for infective and neoplastic processes at various sites Most areas are exposed readily A detailed coverage of the exposure and the excision of the upper end of the fibula is shown in Plate 65



FIG 57 Posturing and draping for operative procedures on the upper end of the fibula

(A) The patient is postured in the lateral position and the trunk is held securely by straps A waterproof covered pillow is placed between the legs and affords a bed for the limb, which is arranged with the knee in slight flexion

(B) The limb has been elevated by the orderly while the foundation sheet was placed beneath it. The upper limit of the field is fixed by a towel clipped round the lower thigh The foot, the ankle and the lower leg have been received and secured in a towel

(C) Stockinet has been rolled over the limb to the lower thigh The leg has been passed through the opening in the laparotomy sheet The stockinet has been incised to expose the field of the operation

PLATE 64

Anterolateral Relations and Exposure of the Tibia

Fractures of the tibia are commonly treated by open reduction and internal fixation The superficial position of this bone greatly facilitates these operative procedures The crest and the anteromedial surface are subcutaneous throughout their length, and the anterolateral surface is readily exposed by reflecting laterally the soft tissues enclosed in the anterior tibial compartment The drawings on this plate have as their purpose the elucidation of the structures included in the anterior tibial compartment and the relation of these structures to the exposure of the anterolateral surface of the tibia

Figure a depicts the skeletal framework of the leg and its articulation with the femur to form the knee joint This framework comprises the tibia and the fibula, joined by the interosseous membrane and at the superior and the inferior tibiofibular joints The anterior tibial vessels enter the compartment by piercing this membrane in its upper part, whereas the deep peroneal nerve reaches its position from the parent nerve trunk by winding round the neck of the fibula The origin of the tibialis anterior muscle is indicated on the tibia From the point of view of the exposure in question, this is the important muscle to note, as it is the main barrier between the neurovascular bundle and the plane of separation in this surgical approach

In b, the extensor hallucis longus and the peroneus brevis are added These muscles form the deep layer of the musculature on the anterior and the lateral aspects of the leg For diagrammatic purposes, the superficial peroneal nerve is slightly displaced to the lateral side

Figure c completes the musculature by adding the tibialis anterior and the extensor digitorum longus, which have a fused origin from the upper ends of the tibia and the fibula and from the interosseous membrane The peroneus longus and the calf muscles are also shown At the ankle, the transverse crural and cruciate ligaments are illustrated These may require section when exposing the lower end of the tibia

The line of incision for the fracture present in d is also indicated in c This is best placed just lateral to the tibial crest to avoid a tender scar which may adhere to the bone The dissection is deepened by incising the deep fascia covering the anterior tibial compartment near the tibial crest The soft tissues are then separated subperiosteally from the anterolateral surface of the bone In d, the medial skin flap is shown widely retracted to expose the subcutaneous anteromedial aspect of the shaft As far as possible, the periosteum is left intact, thus preserving the periosteal blood supply Through this exposure most fractures can readily be inspected and reduced and the various technics of internal fixation by screw, plate or bone graft employed

In young adults, some surgeons prefer exposure of the anteromedial surface with the application of the metallic fixation where it can be more readily removed after union has occurred The extensive ramification of the great saphenous vein and the accompanying saphenous nerve are shown in e These are the structures of surgical significance on this aspect of the leg

(Moseley, H F An Atlas of Surgical Exposures, North Chicago, Abbott)

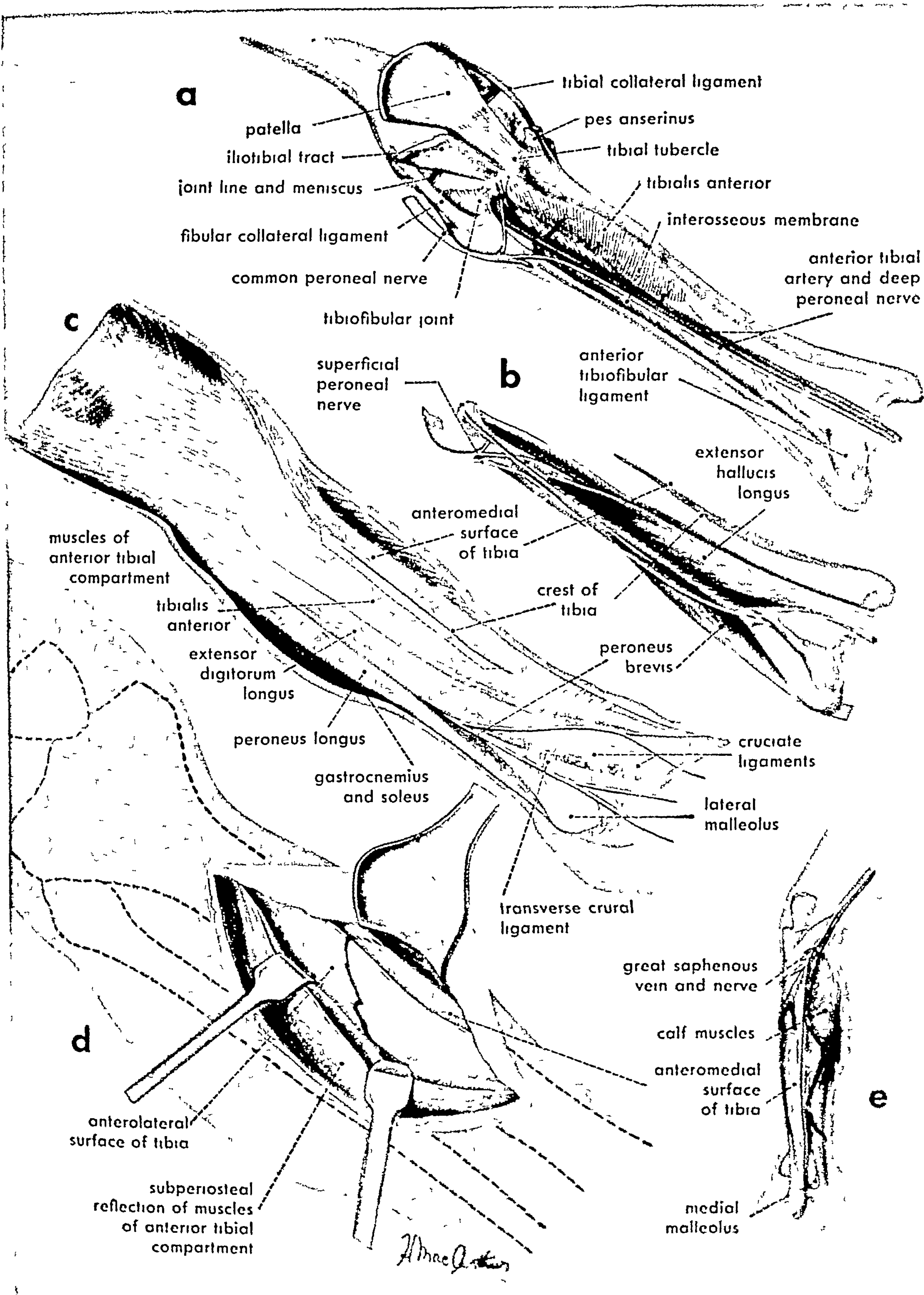

a
tibial collateral ligament
patella
pes anserinus
iliotibial tract
tibial tubercle
joint line and meniscus
tibialis anterior
interosseous membrane
fibular collateral ligament
common peroneal nerve
anterior tibial
artery and deep
peroneal nerve
tibiofibular joint
c
superficial
peroneal
nerve
b
anterior
tibiofibular
ligament
extensor
hallucis
longus
anteromedial
surface
of tibia
muscles of
anterior tibial
compartment
crest of
tibia
tibialis
anterior
extensor
digitorum
longus
peroneus
brevis
peroneus longus
cruciate
ligaments
gastrocnemius
and soleus
lateral
malleolus
transverse crural
ligament
great saphenous
vein and nerve
calf muscles
d
anteromedial
surface
of tibia
e
anterolateral
surface of tibia
subperiosteal
reflection of muscles
of anterior tibial
compartment
medial
malleolus

PLATE 65

Exposure and Excision of the Upper End of the Fibula

The fibula is the secondary bone in the leg, and, with the exception of its lower end which enters into the mortise of the ankle, its ablation leaves little disability Prior to the antibiotics, the rare case of osteomyelitis involving the shaft was well treated by diaphysectomy The upper end may require exposure for neoplasm and sometimes for involvement of the common peroneal nerve secondary to fractures of the neck of the bone

This plate serves to illustrate the relations of the common peroneal nerve to operative procedures, such as resection of the upper end of the fibula

Figure A shows the longitudinal incision in relation to the lateral aspect of the knee and the fibula The skin incision, when deepened, exposes the tendon of the biceps which inserts into the upper end of the fibula The nerve should be found at knee level just behind the tendon of the biceps

In Figure B, the nerve has been isolated and drawn aside by an elastic or tape retractor The biceps tendon has been detached from its insertion on the head of the fibula The peroneus longus anteriorly and the soleus posteriorly have been reflected subperiosteally from the neck and the shaft of the bone The line of section is indicated After division, the end of the fibula is grasped with forceps, and, as it is drawn laterally and proximally, the remaining soft-tissue attachments are divided

If its resection is required for bone grafting or osteomyelitis, the shaft of the fibula can be exposed more distally by following the same plane of soft-part incision and subperiosteal reflection

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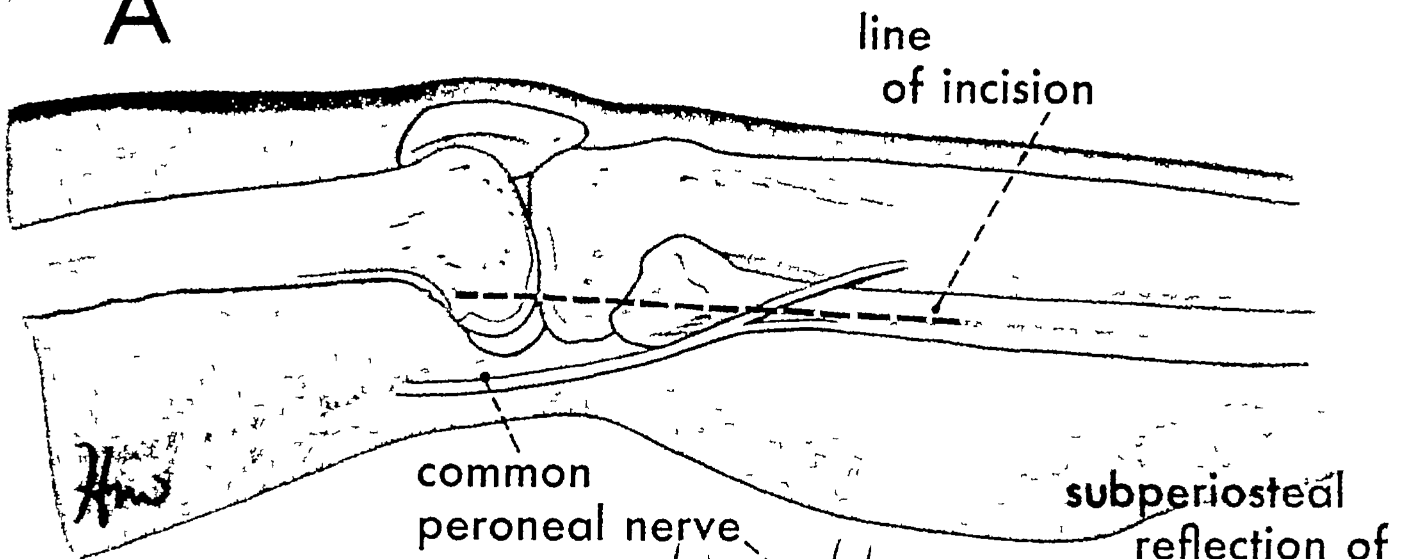
1 Massive Tibial and Iliac Bone Grafts for Nonunion of the Tibia (1947) (By Edwin F Cave, M D, and Carter R Rowe, M D, Boston)

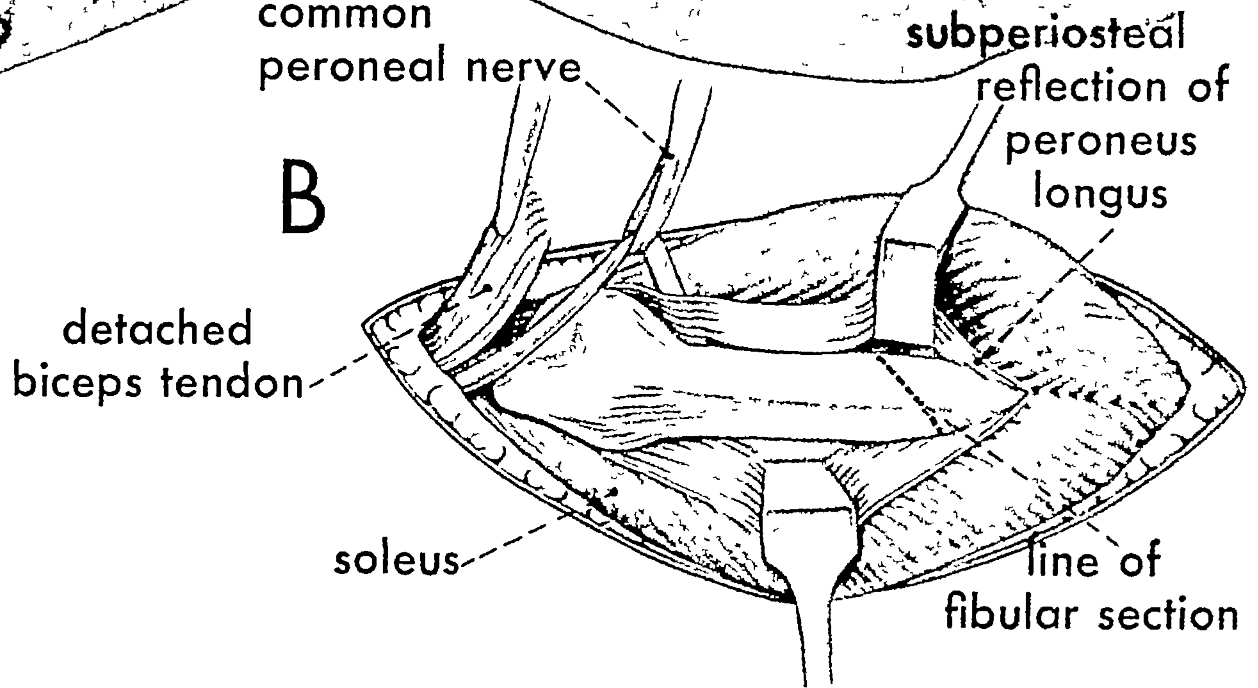
1⅔ reels, 16 mm, silent color *

2 Open Reduction of Tibia and Fibula for Malunion (1947) (By Edwin F Cave, M D, and Carter R Rowe, M D, Boston)

1½ reels, 16 mm, silent color *

* Procurable from Davis & Geck, Inc, 1 Casper St., Danbury, Conn


A
line
of incision
common
peroneal nerve


B
subperiosteal
reflection of
peroneus
longus
detached
biceps tendon
soleus
line of
fibular section

15

THE ANKLE

The *ankle* has been the last major joint of the lower extremity to be subjected to frequent operative exposure and repair of ligamentous and osseous damage due to trauma The mechanistic classifications of its fractures and fracture-dislocations evolved by Dupuytren, Maisonneuve, Ashhurst and Bromer, and lately by Bonnin, should be studied carefully by all surgeons approaching this joint, and the findings on exploration should be correlated with the mechanism of injury The reader is referred to the scholarly work by Mr Bonnin which should serve as a powerful influence in future studies of the post-traumatic anatomy found at operation

In the exposure and the repair of the underlying tissues, skin incisions will be determined by the presence of open wounds and by the sites of major damage deduced from a study of the mechanism of injury and of the preoperative roentgenograms As recognized for injuries of other joints, such as abduction injuries of the knee, standard views should be supplemented, when indicated, by others taken in positions of strain determined by the mechanism of injury This is best carried out under local or general anesthesia to prevent pain and protective muscle spasm

The ankle is a close-fitting mechanism classified in the group of hinge joints The articular surfaces of the talus fit in a mortise whose weight-bearing area is the lower articular surface of the tibia and whose sides are formed by the lateral and the medial malleoli of the fibula and the tibia respectively Tremendous leverage is applied to this mortise by the various forces of external rotation, abduction and adduction which constitute the basis of the common injuries

Operative exposure with reduction and internal fixation is the ideal for avulsion fractures of the internal malleolus and is gaining wide acceptance

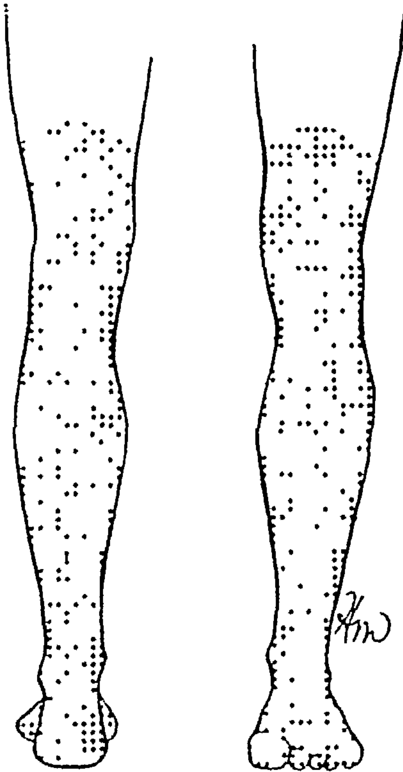


FIG 58 Area of skin preparation for operative procedures on the ankle

The area of skin preparation for operative procedures on the ankle includes the limb from the lower third of the thigh to the toes

The greatest care should be taken in the preparation of the foot Fungous infections and secondary pyogenic infections must be cleared before elective procedures and must be seriously considered in the emergency case The nails should be pared short, and the areas round the nails and between the toes must be cleansed most carefully The approach to toweling the operative field must take into consideration the final state of this part of the area of skin preparation

Anterior and posterior marginal fractures of major size which are not reduced by closed manipulation also require operative correction Diastasis of the inferior tibiofibular syndesmosis, especially if part of a fracture-dislocation of the joint, is frequently best held by screw fixation

Secondary procedures also necessitate exposure for correction of nonunion of the internal malleolar fractures and malunion of the fibula, and for arthrodesis of the joint when traumatic arthritis has ensued

The anatomic relationships in this section have been detailed from the anterior, the posterior, the lateral and the medial aspects of the joint The standard anterolateral, posterolateral, lateral and medial exposures for type fractures and arthrodesis are detailed



Fig 59 Posturing and draping for anterior and posterior exposures of the ankle

The patient is postured in the supine position for the anterior exposure and in the prone position for the posterior exposure

The steps in the draping are comparable

(A) The orderly elevates the limb above table level This is best done by supporting the leg under the upper part of the calf The foundation sheet is placed beneath the leg and over the opposite extremity A sheet is arranged over the trunk and the thigh and down to the upper limit of the field

(B) A towel is clipped round the lower calf Stockinet is rolled over the foot, the ankle and the lower leg Some surgeons prefer to leave the ankle bare and use skin towels to the wound edges

(C) The foot and the ankle are passed through the opening of the laparotomy sheet which is used as a coverall

Plate 66

Anterior and Posterior Relations and Exposures of the Ankle Joint

This plate illustrates the important anterior and posterior relations together with the exposures most generally useful in traumatic cases

Figures a, b and c serve to acquaint the viewer with the anterior relations of the tibiofibular mortise and talus Exploration from this aspect is chiefly valuable for anterior marginal fractures of the tibia and ligamentous rupture in diastasis and for arthrodesis in late cases presenting traumatic arthritis

In a, the articular framework is shown, and especial attention should be given the anterior fibulotalar, tibiofibular and deltoid ligaments The major vessels in this area are the dorsalis pedis artery and vein, which are continuous with the anterior tibial vessels, and the perforating branch of the peroneal artery, which anastomoses with the dorsalis pedis and may replace it

In b, the tendons of the muscles of the anterior tibial compartment with their retaining retinacula are superimposed These are the tibialis anterior, the extensor hallucis longus, the extensor digitorum longus and, finally, the peroneus tertius Laterally, the peroneus longus and brevis wind round the fibula and pass behind the lateral malleolus Cutaneous branches of the peroneal and the long saphenous nerves course over the anterior aspect of the ankle The great saphenous vein passes in front of the medial malleolus

The anterolateral exposure is best for surgical procedures on the front of the joint The line of incision is shown in b, and the approach is detailed in the enlarged view, c When deepened, the dissection follows the tissue planes after section of the retinacula and deep fascia Lateral malleolar and tarsal vessels will be divided near the bone Muscles and tendons, together with the dorsalis pedis vessels, are retracted medially, exposing the anterior margin of the tibia, which is seen fractured in c If the exposure is extended distally, the talonavicular joint may be explored

The posterior relations are depicted in d and e In d, the posterior tibial and peroneal arteries are seen passing medially and laterally The dominant landmark is the tendo achillis, and it is evident that unless this is transected, exposure must be undertaken on its medial or lateral side

In e, the important structures of the posterior tibial compartment are found behind the medial malleolus in their passage to the plantar region of the foot From before backward these are Tibialis posterior, flexor digitorum longus, the posterior tibial vessels and nerve, and, finally, the flexor hallucis longus This last muscle has muscle fibers as low as the joint level and covers the posterior surface of the tibia Laterally, only the peroneus longus and brevis are found with the peroneal artery Thus we can understand that access is best obtained by a posterolateral exposure, as the posteromedial approach encounters all the structures passing behind the medial malleolus

The line of incision is shown in f, together with the visualization of a posterior marginal fracture The tibia is seen after separation of the flexor hallucis longus and peroneal muscles from its surface. Such an approach is secured with the patient in the prone position The foot is plantar flexed to relax the tendo achillis, which is retracted medially with the flexor hallucis longus

The posterolateral exposure is employed for reduction and internal fixation of posterior marginal fractures, for fractures of the fibula in the lower part caused by external rotation, and for diastasis of the tibiofibular syndesmosis

(Moseley, H F An Atlas of Surgical Exposures, North Chicago, Abbott)

a

fibula

tibia

perforating
peroneal
artery

anterior
tibiofibular
ligament

deltoid
ligament

talus

fibular
collateral
ligament

extensor
digitorum
brevis

dorsalis
pedis
artery

peroneus longus
and brevis

extensor
digitorum
longus

tibialis
anterior

b

retinacula

line
of
incision

extensor
hallucis
longus

c

anterolateral
exposure of
marginal fracture
of tibia

anterior views

posterior views

posterolateral
exposure of
posterior marginal
fracture of tibia

d

tibia

fibula

posterior
tibial
artery

peroneal
artery

posterior
surface
of talus

flexor
hallucis
longus

flexor digitorum
longus

tendo achillis

tibialis
posterior

peroneus
longus
and brevis

posterior
tibial vessels
and nerve

e

incision

f

PLATE 67

Lateral and Medial Relations and Exposures of the Ankle Joint

This plate illustrates the lateral and the medial malleoli and the respective collateral ligaments which maintain the integrity of the mortise Fractures of the malleoli and rupture of the ligaments result from forced external rotation, abduction or adduction

Lateral views are shown in Figures a, b and c In a, attention should be given to the three parts of the fibular collateral ligament, namely, the anterior fibulotalar and fibulocalcaneal and the posterior fibulotalar components The fibulocalcaneal ligament, when relaxed, causes the hypermobile ankle, so subject to recurrent sprain on inversion, and this ligament, when ruptured by forced inversion, permits recurrent subluxation of the joint Operative repair of this ligament is, therefore, of increasing frequency as a primary or a secondary procedure

In b, the musculature is superimposed on the skeletal framework Incisions for exposure of the lateral aspect of the fibula may be placed either posteriorly, as indicated in b and published by Gatellier, or anteriorly, as shown by Walker in his film on the transfibular approach for arthrodesis of the ankle

Figure c shows the transfibular exposure of a posterior marginal fracture after Gatellier The fibula is obliquely transected 3½ inches or 4 inches above its lower end or at the line of fracture in the low Dupuytren type of fracture-dislocation It is turned downward on the intact collateral ligament Reduction and internal fixation of a posterior marginal fracture, with subsequent stabilization of the fibular fracture and diastasis, can then be secured Arthrodesis of the ankle joint can be performed by the transfibular exposure as an alternative to employing the anterolateral exposure for this procedure (See Plate 66 a, b and c)

Medial views of the ankle joint are represented in d, e and f In traumatic surgery, exposure with repair of the avulsed medial malleolus or deltoid ligament is probably the commonest operative procedure on this joint

The medial malleolus is readily accessible in its subcutaneous position, with the great saphenous vein and its radicles closely related to its anterior border

In d, the broad thick deltoid ligament is seen spreading out to attach on a wide area of the talus, the navicular and the sustentaculum tali The tendon of the tibialis posterior is held firmly by its fibrous sheath against the posterior surface of the malleolus, from which point it crosses the ligament in its passage into the foot

Incisions to expose the internal malleolus and deltoid ligament may be placed anteriorly, as indicated in f and recommended by Bonnin, or posteriorly, following the course of tibialis posterior, or obliquely across the malleolus from above and behind, downward and forward The anteriorly placed incision gives access to the anterior margin of the tibia and the related capsule, as well as the anterior border of the malleolus It is especially valuable in external rotation injuries with avulsion of the malleolus and tearing of the anterior capsule or marginal fracture

In f, a transverse fracture of the internal malleolus produced by the abduction mechanism is illustrated Periosteum from the adjacent surface of the tibia is usually avulsed with the malleolar fracture as depicted This periosteal cuff may turn into the fracture line and thus prevent adequate reduction which will contribute to nonunion Reduction and internal fixation by screw or suture is readily performed through this medial exposure

(Moseley, H F An Atlas of Surgical Exposures, North Chicago, Abbott)

lateral views

a

fibula

tibia

anterior and posterior talofibular ligaments

talus

os calcis

fibulocalcaneal ligament

peroneal tendons

b

lateral malleolus

superficial peroneal nerve

c

interosseous membrane

tibia

peroneal artery

fibular collateral ligament

reflected fibula

transfibular exposure of posterior marginal fracture of tibia

d

medial views

tibia

posterior tibial artery

talus

deltoid ligament

flexor digitorum longus

geater saphenous vein

flexor hallucis longus

medial malleolus

posterior tibial vessels and nerve

tibialis posterior

e

tibialis posterior

f

exposure of avulsion fracture of medial malleolus

incision

FIG 60 Posturing and draping for lateral and medial exposures of the ankle The patient is placed on the contralateral side for the lateral exposure and on the ipsilateral side for the medial For both positions, a waterproof covered pillow affords a good foundation for the draping The steps are identical with those for anterior and posterior exposures



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Gatellier, Jean The juxtoretroperoneal route in the operative treatment of fracture of the malleolus with posterior marginal fragment, Surg, Gynec & Obst 52 67-70, 1931

Films:

1 Surgical Approaches to the Ankle Joint (the anatomy and surgical approaches to the dorsolateral and medial aspects of the ankle joint are shown by animated diagrams and dissection) (1952) (By LeRoy C Abbott, M D, Robert D Ray, M D, Philip D Wilson, M D, John J Callahan, M D, and J B de C M Saunders, M B, San Francisco)

3 reels, 16 mm, sound color

Procurable from Central Office Film Library, Veterans Administration, Vermont Ave and H St, N W, Washington 25, D C

2 Arthrodesis of the Ankle (1949) (By Guy A Caldwell, M D, New Orleans)

½ reel, 16 mm, silent color

Procurable from Alton Ochsner Medical Foundation, 3503 Prytania St, New Orleans 15, La

3 Subastragalar Arthrodesis (1949) (By H M Coleman, M D, Toronto)

162 feet, 4½ min, 16 mm, silent color

Procurable from Department Medical Illustration Sunnybrook Hospital, Toronto, Ontario

4 Fusion of the Ankle Joint (1947) (By J A Leo Walker, M D, Montreal)

1 reel, 16 mm, silent color

Procurable from Department of Medical Illustration, Queen Mary Veterans' Hospital, Montreal, P Q

16

THE FOOT

The *foot* is prone to many disorders which traumatic and orthopedic surgeons are called upon to ameliorate by operative means This section will present the detailed anatomy which the surgeon must have in mind when performing the necessary dissections in this region The relationships will be considered from the plantar, the medial, the dorsal and the lateral aspects of the foot and the ankle Illustrating the practical application of these anatomic considerations, standard operative procedures for some of the common disorders will be described

Several important factors must be evaluated before any operations on the foot are decided upon

First, and of the utmost significance is the circulatory status of the extremity In any patient from the sixth decade onward, and in any patient presenting Buerger's disease, the greatest care must be taken in evaluating the circulation The healing process is dependent on an adequate blood supply, and the presence of the dorsalis pedis and the posterior tibial pulses is essential before elective procedures can be undertaken

Second, a significant factor is the state of tl skin and the nails It is difficult to cleanse thickened, calloused skin of the heel and the fo foot, but all possible care is needed to sec the best preparation for operation The nails m be pared short and all debris removed The int digital clefts must be cleansed and any fungus pyogenic infection cleared before elective pro dures The thinking surgeon of the aseptic scho of thought does not place his faith in color solutions painted over the poorly prepared sk of the operative field When emergency ope tions are required and such conditions are presen

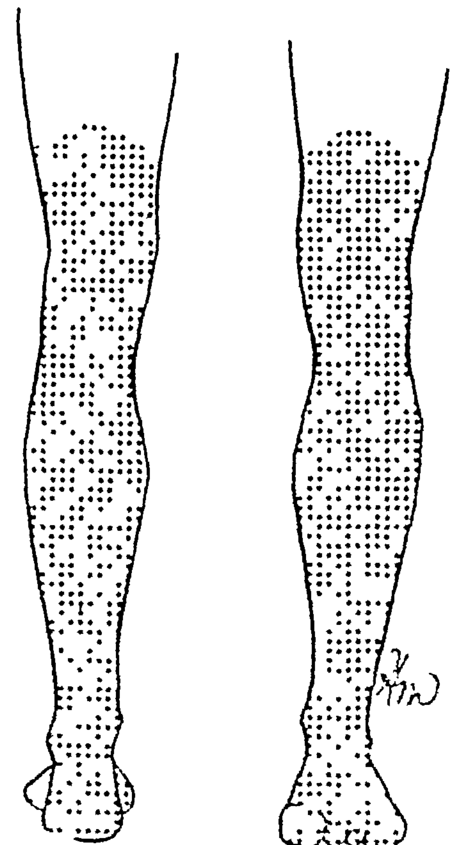


FIG 61 Area of skin preparation for operative procedures on the foot

The area of skin preparation for operative procedures on the foot is similar to that for the leg and the ankle The greatest care must be devoted to the cleansing of the foot and the toes The nails must be pared short, the cuticles cleansed and the interdigital clefts freed mechanically of epithelial debris For elective procedures, preoperative care should clear fungous infections and any secondary infections All procedures of an urgent nature should be delayed when there is evidence of infective processes in the interdigital clefts or round the nails The area of the toes should be excluded from the operative field when possible

the greatest care must be taken to seal off these areas by the method of draping It is hoped that, in time, satisfactory sprays of plastic materials will be available for such purposes

Third, another consideration is the problem of operations on the feet of diabetic patients Whenever possible, operations should be avoided in such cases, but, when required, satisfactory stabilization of the diabetic state must be secured before operation and maintained during the healing period

Finally, when planning the incisions and the operative exposures, the surgeon must take into account the fact that the operative scar is subject to pressure from weight-bearing and from shoes When possible, the incisions should be placed in areas not subject to direct pressure on bone Further, in the postoperative period, protection from pressure by delaying weight-bearing and by correct footwear will facilitate healing and will minimize the tendency of painful scars

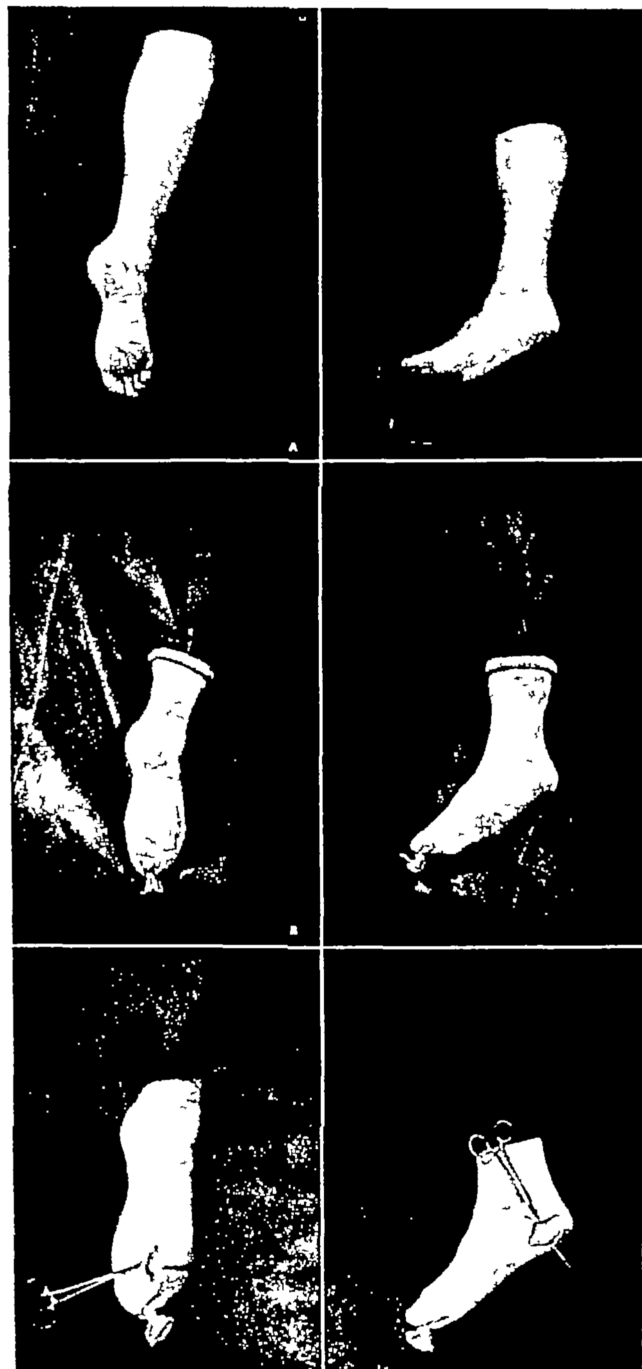


FIG 62 Posturing and draping for operative procedures on the plantar and the medial aspects of the foot

The patient is postured in the prone position for operations on the sole and on the ipsilateral side for operative procedures on the medial aspect of the foot The leg and the foot are best supported on a pillow

(A) The patient is postured and ready for draping

(B) The foot has been supported at the upper part of the leg while the foundation sheet is placed beneath it and over the opposite limb The upper limit of the field has been set by a towel clipped round the lower leg The stockinet is in place

(C) The laparotomy sheet has been laid When possible, operative procedures are carried out through openings in the stockinet Skin edges can be closed off by Michel clipping of the stockinet to them

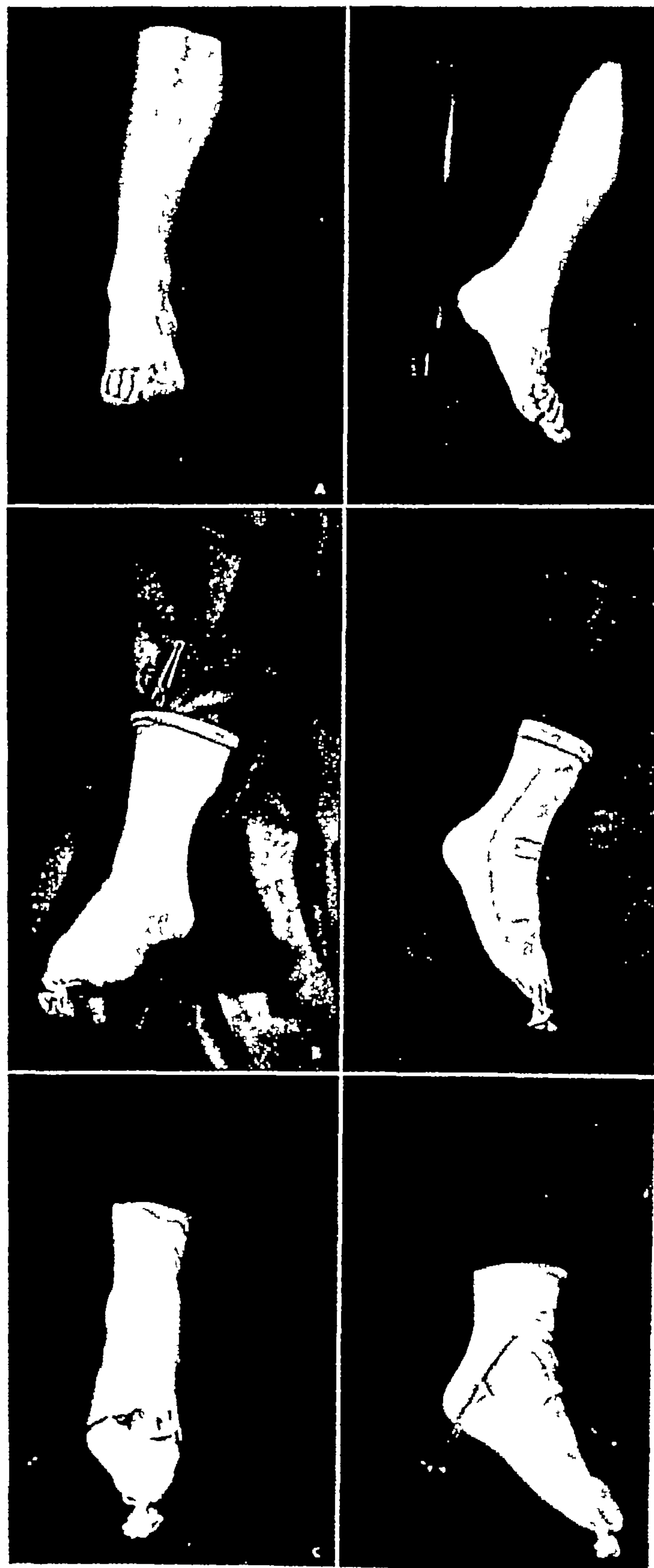


Fig 63 Posturing and draping for operative procedures on the anterior and the lateral aspects of the foot The patient is postured in the supine position for the anterior aspect and on the contralateral side for the lateral A pillow under the leg and the foot is used for support The steps in draping are similar to those for the plantar and the medial aspects

PLATE 68

Plantar Aspect of the Foot

The four drawings of this plate and the first two of Plate 69 illustrate the build-up of the anatomic components of the foot Emphasis is placed chiefly on depicting the relation of the muscles, the tendons and the ligaments to the underlying bones

In Figure A, the deepest layer of muscles and tendons is shown in relation to the skeletal framework

Besides the ligaments and the capsules of the tarsal, the metatarsal and the phalangeal joints, the long plantar and the calcaneonavicular (spring) ligaments should be noted especially

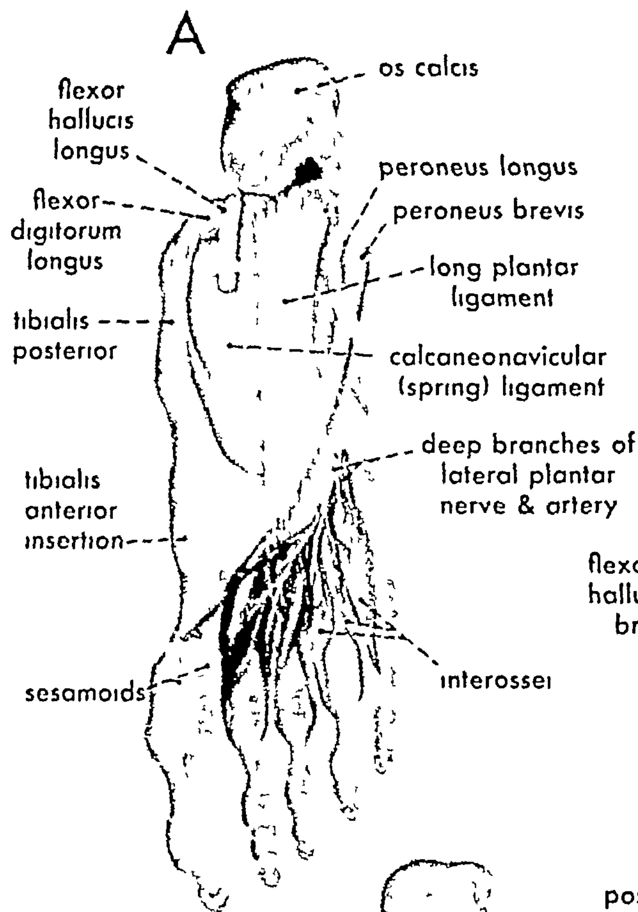
The interossei constitute the deepest layer of muscles and correspond to their counterpart in the hand The important tendons are the opposing groups, the tibialis anterior and posterior on the medial aspect and the peronei longus and brevis on the lateral aspect, controlling the movements of inversion and eversion, respectively

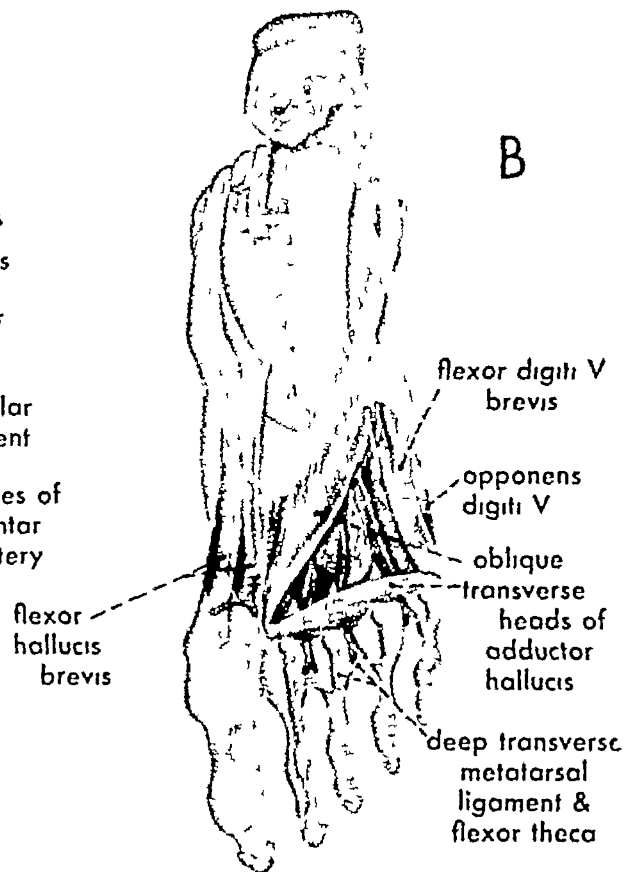
In B, the short flexor of the great and the short flexor and opponens of the little toe are added, together with the adductor hallucis

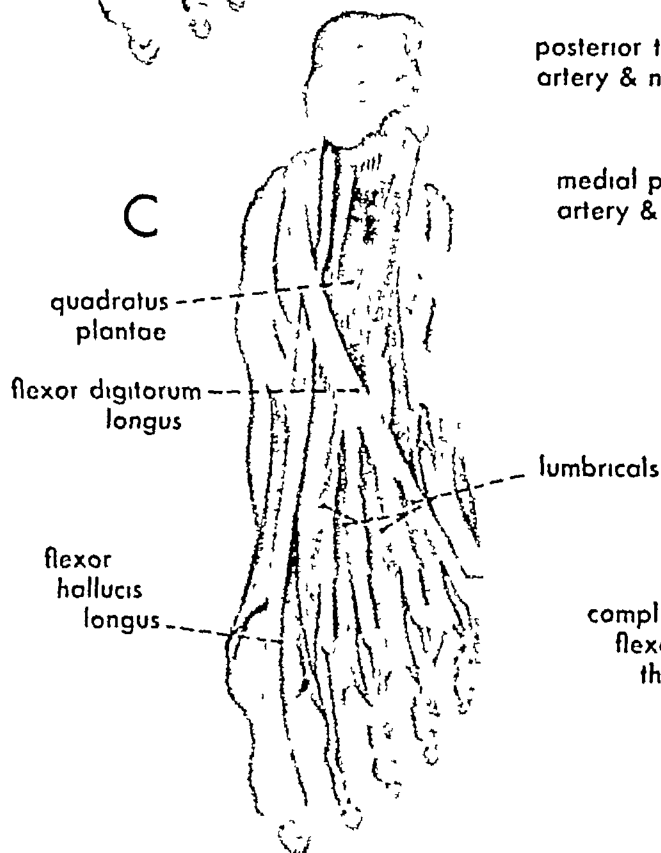
Figure C superimposes the long flexors of the great and the remaining toes The quadratus plantae, aligning the pull of the common flexors to the os calcis, and the lumbricals are also seen

Figure D completes the passage of the tendons and the neurovascular bundle behind the medial malleolus into the sole of the foot These structures, at the malleolar level, are from before backward Tibialis posterior, flexor digitorum longus, posterior tibial vessels and nerve, and the flexor hallucis longus The posterior tibial vessels and nerve divide into the medial and the lateral plantar branches, and the lateral group into the deep and the superficial branches, as depicted

The thecal and the tendon arrangements on the digits correspond with those in the hand


A
os calcis
flexor hallucis longus
flexor digitorum longus
peroneus longus
peroneus brevis
long plantar ligament
tibialis posterior
calcaneonavicular (spring) ligament
deep branches of lateral plantar nerve & artery
tibialis anterior insertion
sesamoids
interossei


B
flexor digiti V brevis
opponens digiti V
oblique
transverse
heads of adductor hallucis
flexor hallucis brevis
deep transverse metatarsal ligament & flexor theca


C
quadratus plantae
flexor digitorum longus
lumbricals
flexor hallucis longus

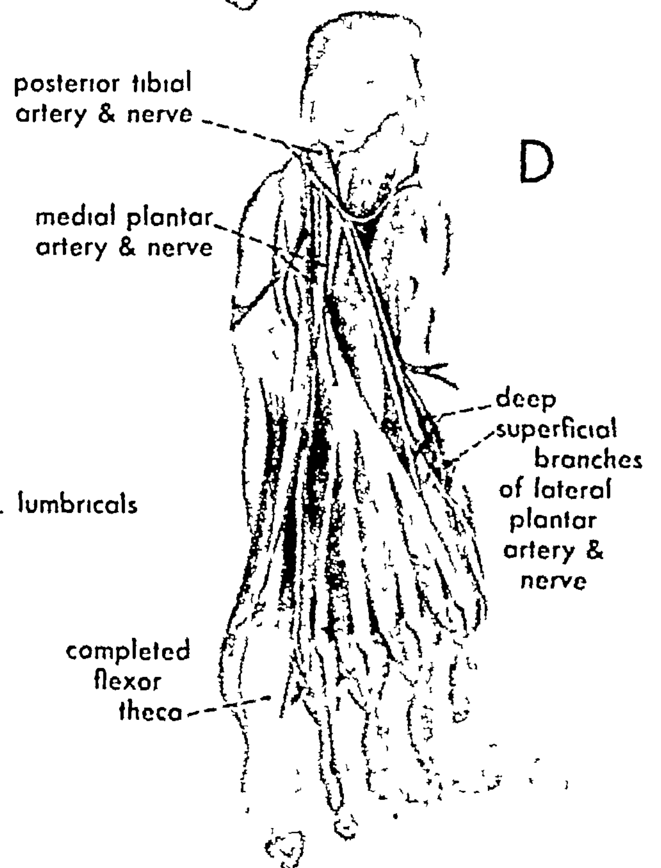

D
posterior tibial artery & nerve
medial plantar artery & nerve
deep
superficial
branches of lateral plantar artery & nerve
completed flexor theca

PLATE 69

Plantar and Medial Aspects of the Foot with Surgical Procedures

Figures E and F continue the series of illustrations of the plantar structures begun on Plate 68

Figure E completes the musculature with the addition of the abductor hallucis, the flexor digitorum brevis and the abductor digiti quinti The arrangement of the tendons, the tendon sheaths, the vessels and the nerves on the digits is illustrated Attention should be directed to the position of the adventitious bursae related to the first and the fifth metatarsophalangeal joints which, when irritated by repeated trauma and deformity, develop into the bunion and the bunionette

Figure F shows the arrangement of the plantar fascia which, like the palmar fascia, may be involved in a Dupuytren-like contracture The lobulated fat pad over the weight-bearing areas of the heel, the lateral aspect of the sole and the metatarsal heads is omitted for simplicity

Figure A illustrates the operative procedure for a plantar neuroma causing the clinical syndrome of Morton's toe The exposure may be made by dorsal or plantar incision, but the latter is preferred and utilized in this instance

Figures B, C and D demonstrate the anatomic relations of the medial aspect of the foot and the exposure and the section of the plantar fascia and the calcaneal spur The thickness of the plantar fat pad should be noted In C, the relation of the fascia and the adventitious bursa to the spur on the os calcis is shown from the medial aspect, whereas in D, the foot is placed so as to indicate the width of the plantar fascia and spur for section

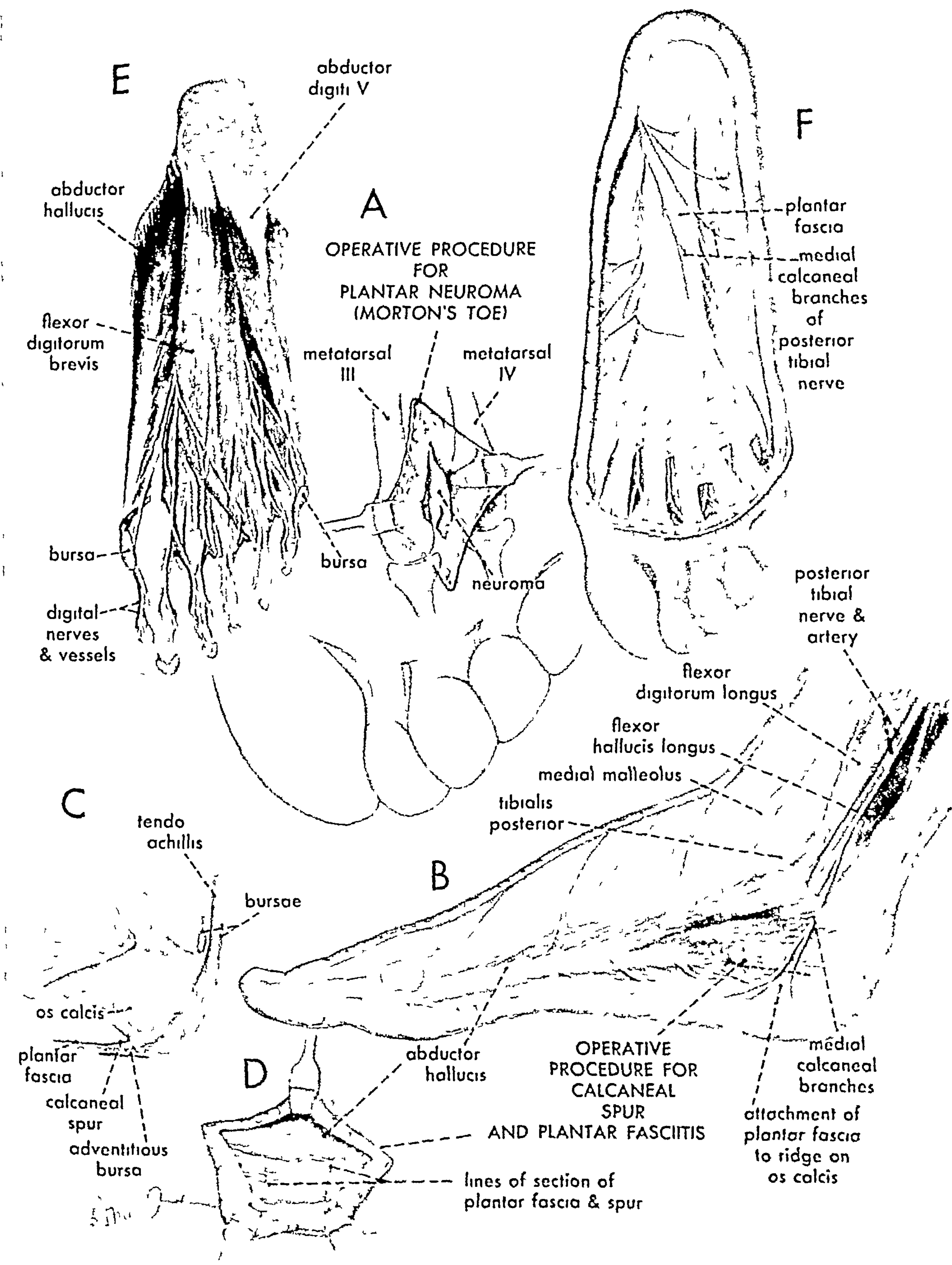

E
abductor digiti V
abductor hallucis
flexor digitorum brevis
bursa
digital nerves & vessels
A
OPERATIVE PROCEDURE FOR PLANTAR NEUROMA (MORTON'S TOE)
metatarsal III
metatarsal IV
bursa
neuroma
F
plantar fascia
medial calcaneal branches of posterior tibial nerve
posterior tibial nerve & artery
flexor digitorum longus
flexor hallucis longus
medial malleolus
tibialis posterior
C
tendo achillis
bursae
os calcis
plantar fascia
calcaneal spur
adventitious bursa
B
D
abductor hallucis
OPERATIVE PROCEDURE FOR CALCANEAL SPUR AND PLANTAR FASCIITIS
medial calcaneal branches
attachment of plantar fascia to ridge on os calcis
lines of section of plantar fascia & spur

PLATE 70

Dorsal Aspect of the Foot with Resection of the Head of the Second Metatarsal

As in the hand, the extensor aspect of the foot is less complicated than the flexor aspect This series should be correlated with those for the ankle (Plate 66)

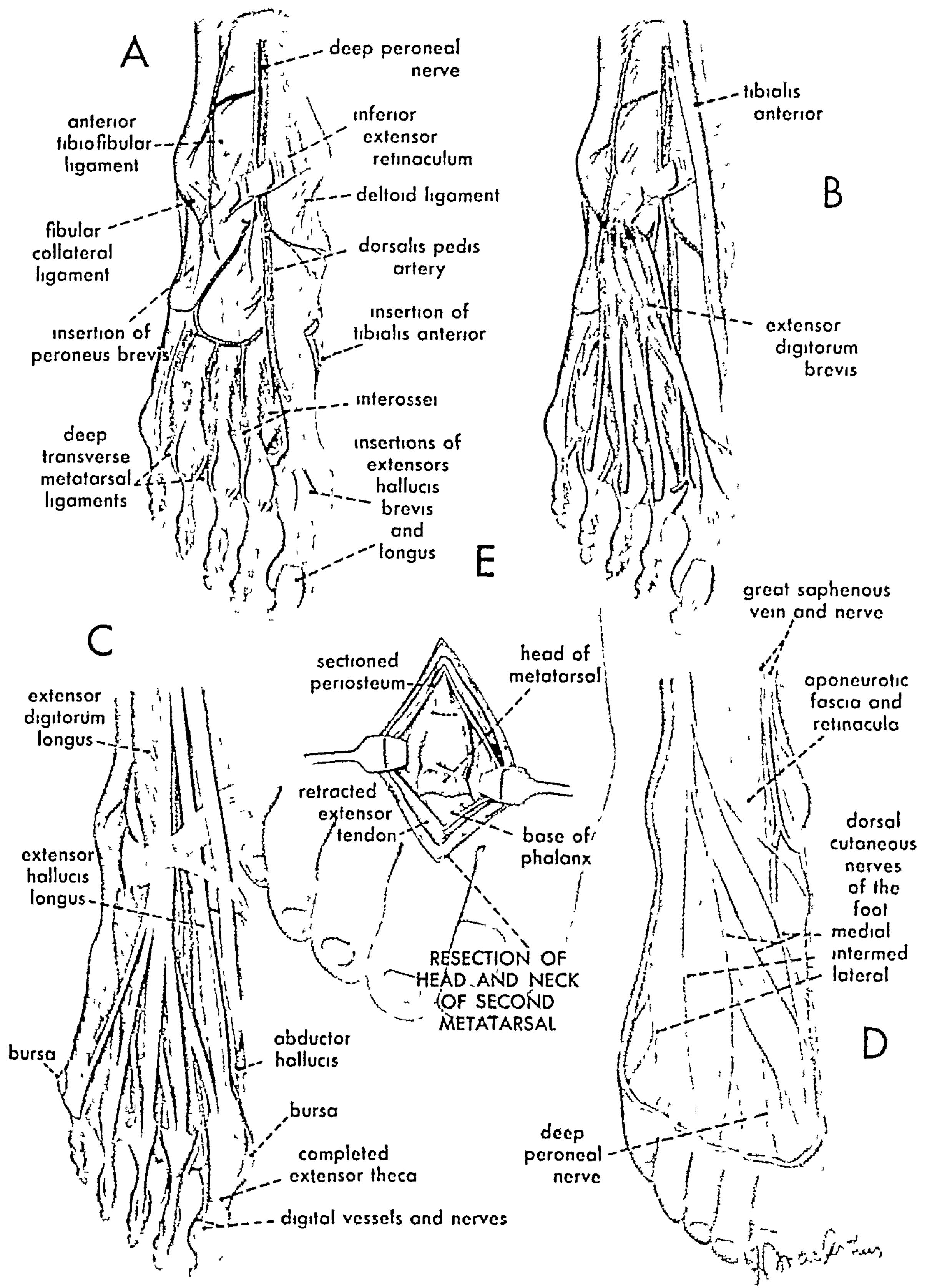
The interossei constitute the deepest layer of muscles and are seen in A inserting into the bases of the proximal phalanges The slips to the extensor tendons are omitted in this drawing The insertions of the extensors hallucis brevis and longus on the great toe and the tibialis anterior on the base of the first metatarsal are shown The important vessel is the dorsalis pedis, which continues the anterior tibial artery and is accompanied by the deep peroneal nerve

Attention should be drawn to the arrangement of the inferior extensor retinaculum illustrated in Figures A, B and C

In B, the extensor brevis and the tibialis anterior tendon are added, while in C, the remaining structures of the anterior tibial compartment, the extensor hallucis longus and the extensor digitorum longus are completed In C, the completed tendon theca on the great toe and the tendon arrangements on the remaining digits should be noted

In D, the aponeurotic deep fascia and retinacula are shown The cutaneous nerves and the great saphenous vein are superimposed

Resection of the head of the second metatarsal may be required in the Morton's type foot with hypertrophic changes in the metatarsophalangeal joint and plantar callus formation The bone is exposed readily through a short longitudinal incision and sectioned along the dotted line which is shown in E



A
deep peroneal nerve
anterior tibiofibular ligament
inferior extensor retinaculum
deltoid ligament
fibular collateral ligament
dorsalis pedis artery
insertion of peroneus brevis
insertion of tibialis anterior
interossei
deep transverse metatarsal ligaments
insertions of extensors hallucis brevis and longus
B
tibialis anterior
extensor digitorum brevis
E
C
extensor digitorum longus
extensor hallucis longus
sectioned periosteum
head of metatarsal
retracted extensor tendon
base of phalanx
RESECTION OF HEAD AND NECK OF SECOND METATARSAL
bursa
abductor hallucis
bursa
completed extensor theca
digital vessels and nerves
great saphenous vein and nerve
aponeurotic fascia and retinacula
dorsal cutaneous nerves of the foot
medial
intermed
lateral
D
deep peroneal nerve

PLATE 71

Operative Exposures and Procedures

The first three drawings on this plate illustrate the surgical anatomy on which the operative procedure subtalar-midtarsal (so-called triple) arthrodesis is based

The dorsolateral aspect of the foot presents no important nerves or blood vessels which must be avoided Special attention should be paid to the peroneal tendons, which can be mobilized and retracted as required, and also to the extensor digitorum brevis, which is reflected from its origin The soft tissues are reflected widely, exposing the subtalar, the calcaneocuboid and the talonavicular joints The capsules are sectioned and the joints opened by forced inversion for removal of the cartilage

In B, the series of drawings represent a useful procedure for the correction of hammer toe Through an elliptical incision, the callus over the prominent joint is excised, the extensor tendon is sectioned and the joint is opened The cartilage of the joint is removed and tenotomy of the flexor tendon is performed The toe is manipulated into a straightened position, and a Kirschner wire is inserted to maintain the correct position The dorsal wound is sutured The end of the wire is left under the skin for removal after four weeks with the assistance of procaine infiltration

In C, the exposure of the metatarsophalangeal joint of the great toe is presented for the correction of hallux valgus In this instance, the base of the proximal phalanx and prominent exostosis are removed, as in the Keller operation This would be followed by the suture of a flap of the medial soft tissues across the raw bone in the joint space

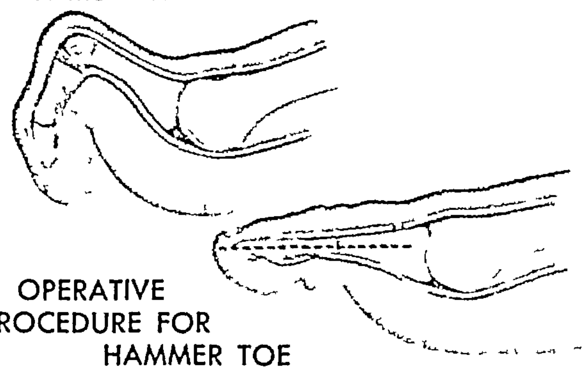
Figure D shows the corresponding lesion, or bunionette, on the lateral side of the foot The exposure is made readily through a dorsal incision, and the soft parts are reflected to expose the joint and component bones Resection of the metatarsal head and prominent lateral portion of the base of the phalanx is illustrated here.

A

TRIPLE ARTHRODESIS

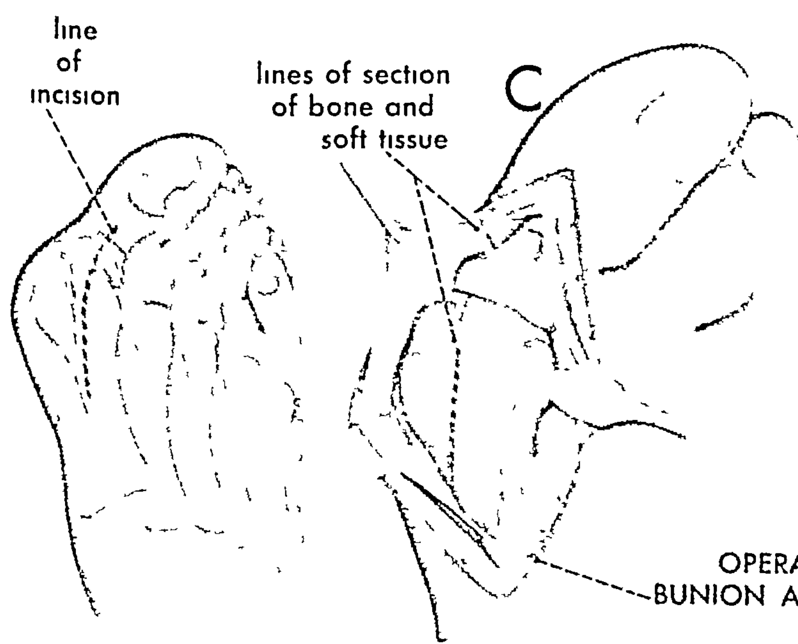
extensor digitorum longus
fibula
calcaneus
extensor digitorum brevis
talus
navicular
cuboid
sinus tarsi
peroneal tendons
line of incision
lines of joint resection
extensor digitorum brevis
extensor digitorum longus
abductor digiti V
lateral
intermediate } dorsal cutaneous nerves of the foot

B

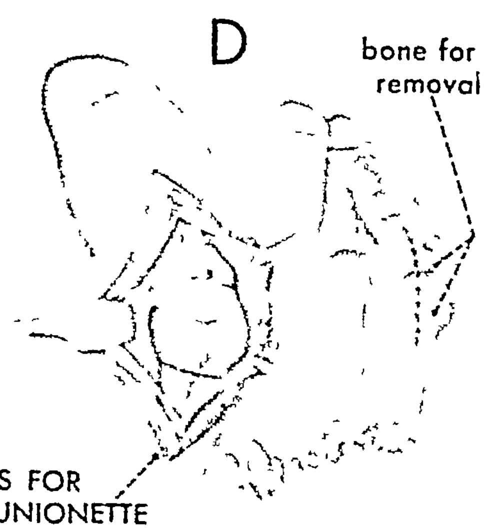


OPERATIVE PROCEDURE FOR HAMMER TOE

C



D



OPERATIONS FOR BUNION AND BUNIONETTE

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3 reels, 16 mm, sound color

Procurable from Central Office Film Library, Veterans Administration, Vermont Ave and H St, N W, Washington 25, D C

2 Triple Arthrodesis of the Foot (1948) (By Guy A Caldwell, M D, New Orleans)

1½ reels, 16 mm, silent color

Procurable from Alton Ochsner Medical Foundation, 3503 Prytania St, New Orleans 15, La

3 Plantar Neuroma (1950)

1¼ reels, 16 mm, silent color

Procurable from Lyon K Loomis, M D, 116 S Jefferson Davis Parkway, New Orleans, La

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